

Design and Implementation of a Remotely Controlled Electronic Door Lock

By

Rabab Osman Mohammed Said Farh
B.Sc. (HONOUR) in Telecommunication,
University of Gezira, 2003

A Thesis Submitted to the University of Khartoum as a
Partial Fulfillment of the Requirements for the degree of
M.Sc. in Computer Architecture and Networking

Supervisor:

Professor: Sharief F. Babikir

Department of Electrical and Electronic Engineering
Faculty of Engineering

January 2015

قال الله تعالى:

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

{ويرى الذين أوتوا العلم الذي
أنزل إليك من ربك هو الحق ويهدى
إلى صراط العزيز الحميد}

صدق الله العظيم

سورة سبأ الآية (5)

Dedication

To my sister **Rihab Osman** who supported to do my best in
life, study, work ...

Acknowledgement

II

Thanks first and last to ALLAAH who enabled me to conduct this study by grace of him and gave me strength. For all those who stood by me, and helped me in this thesis, I send my thanks and deepest gratitude.

Special and deepest regards to my supervisor **Prof. Sharief Fadul Babiker** for his continuous supports, help and patience.

Last but not least, special thanks are to my friends who have shared their opinions and useful information as well as the technical support to me in order to complete the project.

Abstract

This thesis describes the design and implementation of a Microcontroller based security system. It provides users with an efficient and reliable security system that supports the use of an electronic keypad or mobile phone, Dual Tone Multiple Frequency (DTMF) arranged to send signals to the control unit. The system provides the ability to authenticate the user and to on lock the entry point.

The system was implemented using a microcontroller interfaced to a DTMF decoder together with a stepper motor. The system has been successfully tested under normal operating conditions and this system was found to provide the expected functionality.

المستخلص

هذا البحث يصف تصميم وتهيئة نظام حماية يعتمد على المتحكم الدقيق ويزود المستخدم بنظام ذو كفاءة وفاعلية وهذا النظام يستخدم فيه لوحة المفاتيح اوالهاتف الجوال، تردد النغمة الثنائية المتعدّد (دي .تى . أم .اف) لإرسال إشارة لوحدة التحكم. والنظام يزود المستخدم بمقدرة على التحكم فى نقاط الوصول.

هذا النظام تم تهيئة بإستخدام المتحكم الدقيق بتوصيلها مع (دي .تى . أم .اف) وتوصيلهما بالموتور. تم إختبار وتشغيل هذا النظام على الطبيعة حيث انه يؤدى المهام والوظائف المطلوبة من تصميمه.

Table of Contents

Title	Page No.
Chapter One: Introduction	
Background	1
1.1 Problem Definition	1
1.2 Objectives	2
1.3 Methodology.....	2
1.4 Thesis Layout.....	2
Chapter Two: Literature Review	
Introduction	4
2.1 Biometric System.....	5
2.2 Similar Study	8
2.3 PIC Microcontroller.....	9
Chapter Three: System Design	
Introduction	10
3.1 System flow chart.....	11
3.2 Introduction to Proteus Software.....	12
3.3 MikroC PRO for PIC.....	13
3.4 System Circuit Diagram.....	14
3.5 PIC K150 programmer.....	16
3.6 Dual Tone Multiple Frequency (DTMF)	17
3.7 Stepper Motor.....	20
3.8 Keypad Interface with Microcontroller.....	22
3.9 Interfacing LCD with Microcontroller	23
Chapter Four: Result and discussions	
4.1 Simulation Results and discussions	24
4.2 Results of hardware construction.....	29
Chapter Five: Conclusion and Recommendation	
5.1 Conclusions.....	34
5.2 Recommendations.....	34
References.....	36
Appendices	
Appendix A (Project code)	
Appendix B (PIC 16F877A Data Sheet)	
Appendix C (ULN2803)	
Appendix D (MT8870)	

List of Figures

Figure Name	Page No.
Figure (3.1) - Block diagram the door lock.....	10
Figure (3.2) - System Flow Chart.....	11
Figure (3.3) - Proteus simulation program.....	12
Figure (3.4) - MikroC program for PIC.....	13
Figure (3.5) - Circuit diagram of the door lock controller.....	15
Figure (3.6) - PIC k150 programmer.....	16
Figure (3.7) - Functional Block Diagram of MT8870.....	17
Figure (3.8) - MT8870 Single-Ended Input Configuration.....	18
Figure (3.9) - Stepper motor.....	20
Figure (3.10) - ULN 2803 interface to stepper motor.....	21
Figure (3.11) - Keypad 4*4.....	22
Figure (3.12) - LCD 16*2 Pin Diagram.....	23
Figure of Result in Simulation program	
Figure (4.1) - System design in proteus program.....	24
Figure (4.2) - Initial state of system	24
Figure (4.3) - system waiting password from keypad.....	25
Figure (4.4) - Entering password to system from keypad.....	25
Figure (4.5) - Motor is activated in order to unlock the door.....	26
Figure (4.6) - Motor is activated in order to lock the door	26
Figure (4.7) - system waiting password from Mobile.....	27
Figure (4.8) - system message when entered password is wrong. ...	28
Figure of Results of hardware construction	
Figure (4.9) - System hardware design.....	29
Figure (4.10) - Initial state of system.....	29
Figure (4.11) - system waiting password from keypad.....	30
Figure (4.12) - Entering password to system from keypad.....	30
Figure (4.13) - Motor is activated in order to unlock the door.....	31
Figure (4.14) - Motor is activated in order to lock the door.....	31
Figure (4.15) - system waiting password from Mobile.....	32
Figure (4.16) - system message when entered password is wrong...	33
Figure (4.17) - Overall system and desired output.....	33

List of Tables

Table Name	Pages No.
Table (3.1) - DTMF keypad frequencies.....	19
Table (3.2) - Digit coding.....	19
Table (3.3) - Four different steps of stepper motor.....	21
Table (3.4) - Connect keypad in PORTD.....	22
Table (3.6) - LCD 16*2 Pin Description.....	23

List of Abbreviations

ANSI	American National Standards Institute
CISC	Complex Instruction Set Computing
CPU	Central Processing Unit
DTMF	Dual-Tone Multiple Frequency
EMF	Electromotive Force
I/O	Input/ Output
IDE	Integrated Development Environment
LCD	Liquid Crystal Display
LD	Loop disconnect
OACS	Office Access Control System
PIC	Programmable Interface Controller
RISC	Reduced Instruction Set Computing

Chapter One

Introduction

Chapter One

Introduction

Background

Efficient and reliable security systems are needed for most access point. Traditional keys may be forgotten anywhere, also remote access control may be needed for those who are far away and while someone should access the point without been informed of the required access password.

1.1. Problem Definition

Devices such as motion detectors, light detectors among others are susceptible to be triggered by false signals such as noise impulses, whenever its sensitivity is increased. They are not suitable for most outdoor security protection due to the fact that they don't possess high discriminative capability during operation and they are fairly expensive.

It is hence imperative to provide a locking device, one which is suitable for outdoor security protection also efficient, reliable and low cost. It includes using correct personal identification numbers to operate the locking device.

The automatic lock finds application in homes, banks in the field of military applications i.e. ammunition ware house and industries etc.

1.2. Objectives

To design and build a low-cost, keyless security system using keypad build in the access point or mobile phone (DTMF) if it is required to open the door for kids or relatives when the user or owner is far away from the access point .

1.3. Methodology

In this project Proteus simulation program will be used to design the electronic circuit with microcontroller as the main control unit, C code will be written using MikroC Compiler, the code will be burned to PIC16F877A using PIC k150 programmer, the circuit will be designed, analyzed and tested. The modules considered in this project are (The keypad unit, Mobile phone (DTMF) unit, display unit, output motor (ULN2803+ MOTOR) unit.

1.4. Thesis Layout

Chapter two (Literature Review) gives an introduction to door lock system, Biometric System, Similar Study and PIC Microcontroller.

Chapter three (system design) this chapter discusses proteus simulation program, mikroC compiler, PIC k150 programmer and circuit of the project. This chapter discusses all software and hardware that used to build door lock system.

Chapter four (Result): this chapter discusses results of the project started with results of simulation in proteus program and results of hardware construction.

Chapter five (conclusion and Recommendations): this chapter contains the conclusion that can be drawn from this thesis, based on the work introduced by chapter four. Also contains some of recommendation to develop this system in the future.

Chapter Two

Literature Review

Chapter Two

Literature Review

Access control security systems are used as selective systems to decide who can access a given location based on a personal distinctive trait of the user. From the past time to the present, security locks usually include mechanical devices made of forged metal, door chain, pin tumbler lock, jam lock and padlock etc.

Other recently developed security devices are gadgets like laser beam detectors, motion detectors and magnetic card readers. Most recent of these devices are offshoots of biometric engineering. They include voice recognition systems, finger print readers, retina eye scanners ...etc.

The major characteristic of security devices is to prevent an intruder from gaining access to a location. Most of these devices, however, have lapses and loophole which may give an unauthorized person access to location where they are barred.

The simple jam lock and pad lock can be forced open or the keys duplicated by unauthorized persons and under certain conditions, physical changes of the individual concerned, the biometric devices sometimes fail in recognizing the authentic individual concerned.

Hence they cannot be totally relied on. Furthermore, these devices are very expensive, their use is restricted only to few individuals or organizations that can afford it.

2.1 Biometric System

Biometrics is defined as the unique (personal) physical/logical characteristics or traits of human body. These characteristics and traits are used to identify each human. Any details of the human body which differs from one human to other will be used as unique biometric data to serve as that person's unique identification (ID), such as: retinal, iris, fingerprint, palm print and DNA. Biometric systems will collect and store this data in order to use it for verifying personal identity. The combination of biometric data systems and biometrics recognition/identification technologies creates the biometric security systems [1].

2.1.1 Facial Recognition Detector

The human face is one of the characteristic which can be used in biometric security system to identify a user. Face recognition technology, is very popular and is used more widely because it does not require any kind of physical contact between the users and device. Cameras scan the user face and match it to a database for verification. Furthermore, it is easy to install and does not require any expensive hardware. Facial recognition technology is used widely in a variety of security systems such as physical access control or computer user accounts. However, it is still not as unique as its counterparts such as retinal, iris or DNA. Therefore, it is normally used with other characteristics in the system. On the other hand, time is the most negative affective factor with face recognition technology because as the user ages will change over time [1].

2.1.2 Fingerprint Reader

Our fingerprint is made of a number of ridges and valley on the surface of finger that are unique to each human. "Ridges are the upper skin layer segments of the finger".

There are several benefits of using fingerprint recognition systems. This system is easy to use and install. Equipment has low power consumption. However, there are some disadvantages in this system. If the surface of the finger gets damaged and/or has one or more marks on it, identification becomes increasingly hard. Furthermore, the system requires the users' finger surface to have a point of minutiae or pattern in order to have matching images. This will be a limitation factor for the security of the algorithm [1].

2.1.3 Voice Recognition

There are two main factors which makes a person's voice unique. Firstly, it is the physiological component which is known as the voice tract. Secondly, it is a behavioral component which is known as the voice accent. By combining both of these factors, it is almost impossible to imitate another person's voice exactly and unauthorized users can record authorized users' voices and run it through the verification process in order to get user access control to system [1].

2.1.4 Iris Scanner & Recognition

The human iris is a thin circular structure in the eyes which is responsible for controlling the diameter and size of the pupils. It also controls the amount of light which is allowed through to retinal in order to protect the eye's retina. Iris color is also a variable different to each person depending upon their genes. Iris color will decide eye color for each individual. Iris recognition systems will scan the iris in

different ways. It will analyze over 200 points of the iris including: rings, furrows, freckles, the corona and others characteristics. After recording data from each individual, it will save the information in a database for future use in comparing it every time a user want to access to the system [1].

2.1.5 Veins Recognition

One of the recent biometric technologies invented is the vein recognition system. Veins are blood vessels that carry blood to the heart. Each person's veins have unique physical and behavioral traits. Taking advantage of this, biometrics uses unique characteristics of the veins as a method to identify the user. Vein recognition systems mainly focus on the veins in the users hands. Each finger on human hand has veins which connect directly with the heart and it has its own physical traits [1].

2.1.6 DNA Biometrics System

One of biometrics technology which is used in security systems recently is DNA biometrics. It is impossible to fake this characteristic because each person's DNA is unique. Each person's DNA contains some trait from his/her parents. Each cell in the human body contains a copy of this DNA. DNA profiling will decide the amount of VNTR (variable number tandem repeat) which repeats at a number of distinctive loci. These amounts of VNTR will make up an individual's DNA profile [1].

Because of time is the negative affective for facial recognition detector, for fingerprint reader if the surface of the finger gets damaged it will be difficult to match, for Voice Recognition unauthorized users can record authorized users' voices and run it through the verification

process in order to get user access control to system...and for many other reason password access control system are useful [1].

2.2 Similar Studies

Alternative House Security System designed by Rachit Saini Jerry Shim Qi Zhao [2]. Design a personal and home security system that requires nothing to carry, like keys or cards. However, the resident himself can activate and enters the home. The system prevents a person from getting locked out of their home if they forget to grab their key before leaving. The system project was chosen because there are not any non-expensive ways to get into the house using biometrics.

The functions of their security system is doorknob which activate the system by detecting the (Height - weight - Eye blinking) unlocking the door if all identifications match [2].

Microcontroller-Based Lock Using Color Security Code was designed by Then Dao Hui [3]. The main objective of this design is to develop a security system that uses the color sequence as authentication method. The color of the button to key in the color code is changing randomly. It creates a security lock that can reduce the probability of password being stolen by bystander in such a way that the passwords pressed are difficult to be guessed by others nearby.

Firstly, the security lock is aimed to use for door locking system using microcontroller as the controller. Secondly, there will be at least 3 colors changing randomly for each key of the keypad. Third, the color will be changed when one of the keys (button) is pressed or 5s had elapsed without any key pressed [3].

A Private Office Access Control System (OACS) was designed by Sadeque Reza Khan [4]. This is a flexible and low cost modular system based on integration of keypad, magnetic lock and a

microcontroller, is used as a main controller. The main controller obtains a user password from a keypad. If the password is correct then it will permit the access of a valid user by controlling an electromagnetic door lock. For an invalid password the system will stack and blow protection alarm [4].

2.3 PIC Microcontrollers

Microcontrollers are single-chip computers consisting of Central Processing Unit (CPU), data and program memory, serial and parallel input/output (I/O) ... etc [5].

Microcontrollers are programmed devices. A program is a sequence of instructions that tell the microcontroller what to do [5].

Programmable Interface Controller (PIC) microcontrollers are manufactured in different sizes and in varying complexity. These microcontrollers incorporate Reduced Instruction Set Computer (RISC) architecture and there is only a small set of instructions that the user has to learn. Also, the power consumption of PIC microcontrollers is very low and this is one of the reasons which make these microcontrollers popular in portable hand-held applications [6].

Chapter Three

System Design

Chapter Three

System Design

The project is divided into two parts; namely hardware and software. Each part will be analyzed separately. Proteus simulation program used to design the electronic circuit with microcontroller as the main control unit, C code written using MikroC Compiler. The code was burned to PIC16F877A using PIC k150 programmer. The circuit was designed, analyzed and tested. The modules considered in this project are: the keypad unit, mobile phone (DTMF) unit, display unit, output motor (ULN2803+ Motor) unit.

The block diagram of the microcontroller based Electronic door lock is shown below:

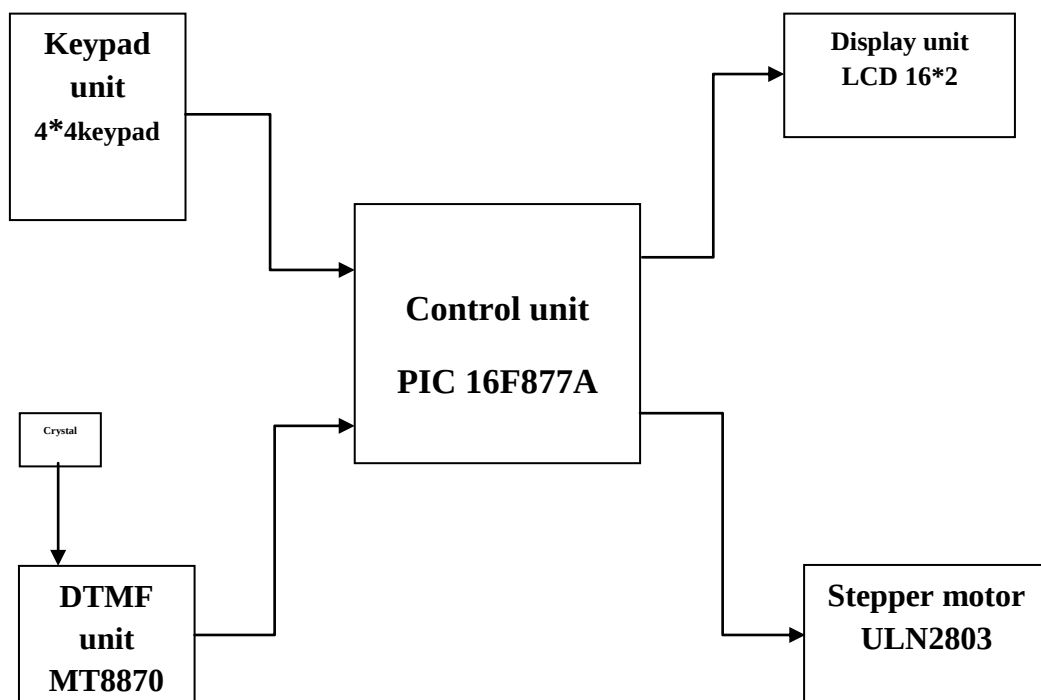


Figure (3.1) - Block diagram of the door lock

3.1 System Flowchart

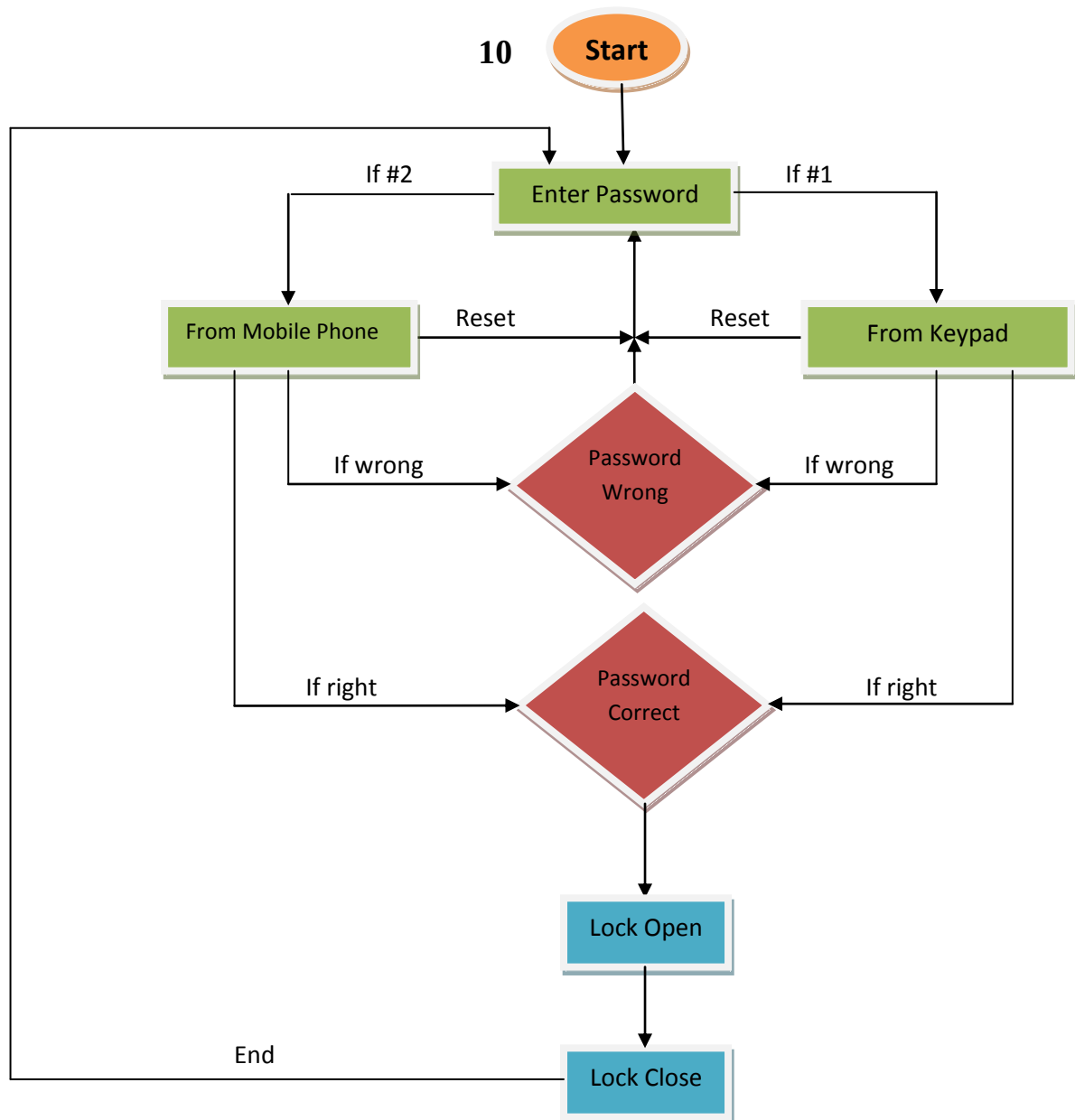


Figure (3.2) – System flowchart

3.2 Introduction to Proteus Software

Proteus is best simulation software for various designs with microcontroller. It is mainly popular because of availability of almost all microcontrollers in it. So it is a handy tool to test programs and embedded designs for electronics hobbyist. It is possible to simulate and test programs of microcontroller in Proteus Simulation Software [7].

After simulating the circuit in Proteus Software it will be easy to make a PCB design with it so it could be all in one package .

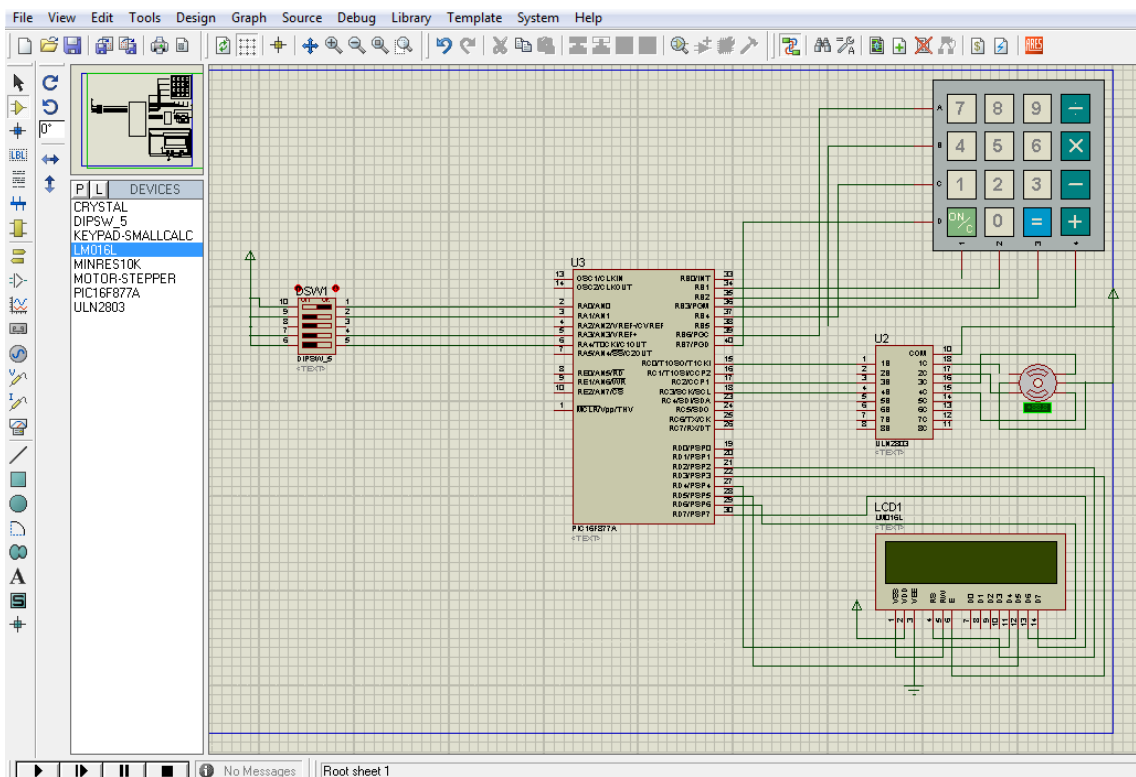


Figure (3.3) - Proteus simulation program

3.3 MikroC PRO for PIC

The mikroC PRO for PIC is a powerful, feature-rich development tool for PIC microcontrollers. It is designed to provide the programmer with the easiest possible solution to developing applications for embedded systems, without compromising performance or control [8].

PIC and C fit together well, PIC is the most popular 8-bit chip in the world, used in a wide variety of applications, and C, prized for its efficiency, is the natural choice for developing embedded systems. MikroC PRO for PIC provides a successful match featuring highly advanced IDE, ANSI compliant compiler, broad set of hardware libraries, comprehensive documentation, and plenty of ready-to-run examples [8].

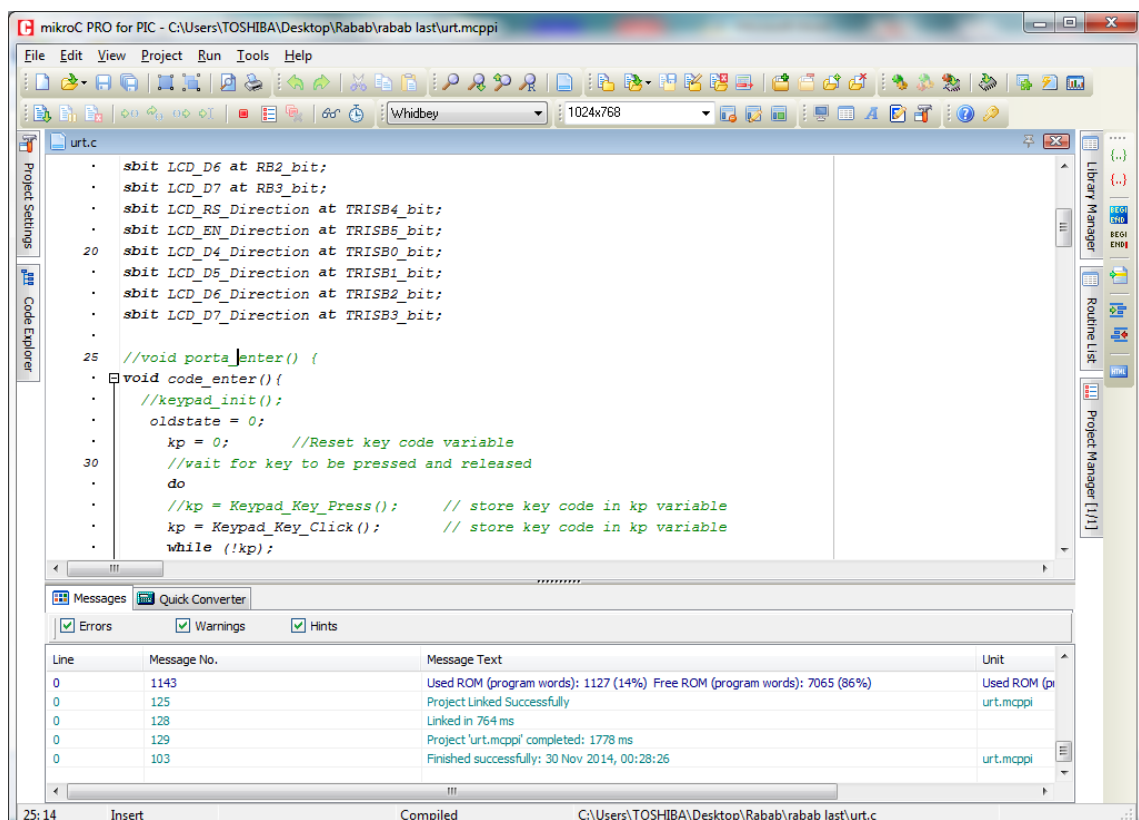


Figure (3.4) - MikroC program for PIC

3.4 System Circuit Diagram

The main control unit is PIC16F877A has five ports (A – B – C – D – E). Port E is not used in this project.

DTMF (MT8870) is interfaced to the main control unit through Port A (A0-A4) as the inputs for the system.

The keypad is interfaced to the main control unit through Port B (B0-B7), as the inputs for the system.

A 16*2 LCD is the output for the system that displays the status of the system; it interfaces to the main control unit through Port D (D2-D7).

A motor drive is the output for the system that represents the lock of the door. Motor drive connects to the microcontroller using the integrated circuit ULN2803.

ULN2803 interfaces to the main control unit through Port C (C0-C3).

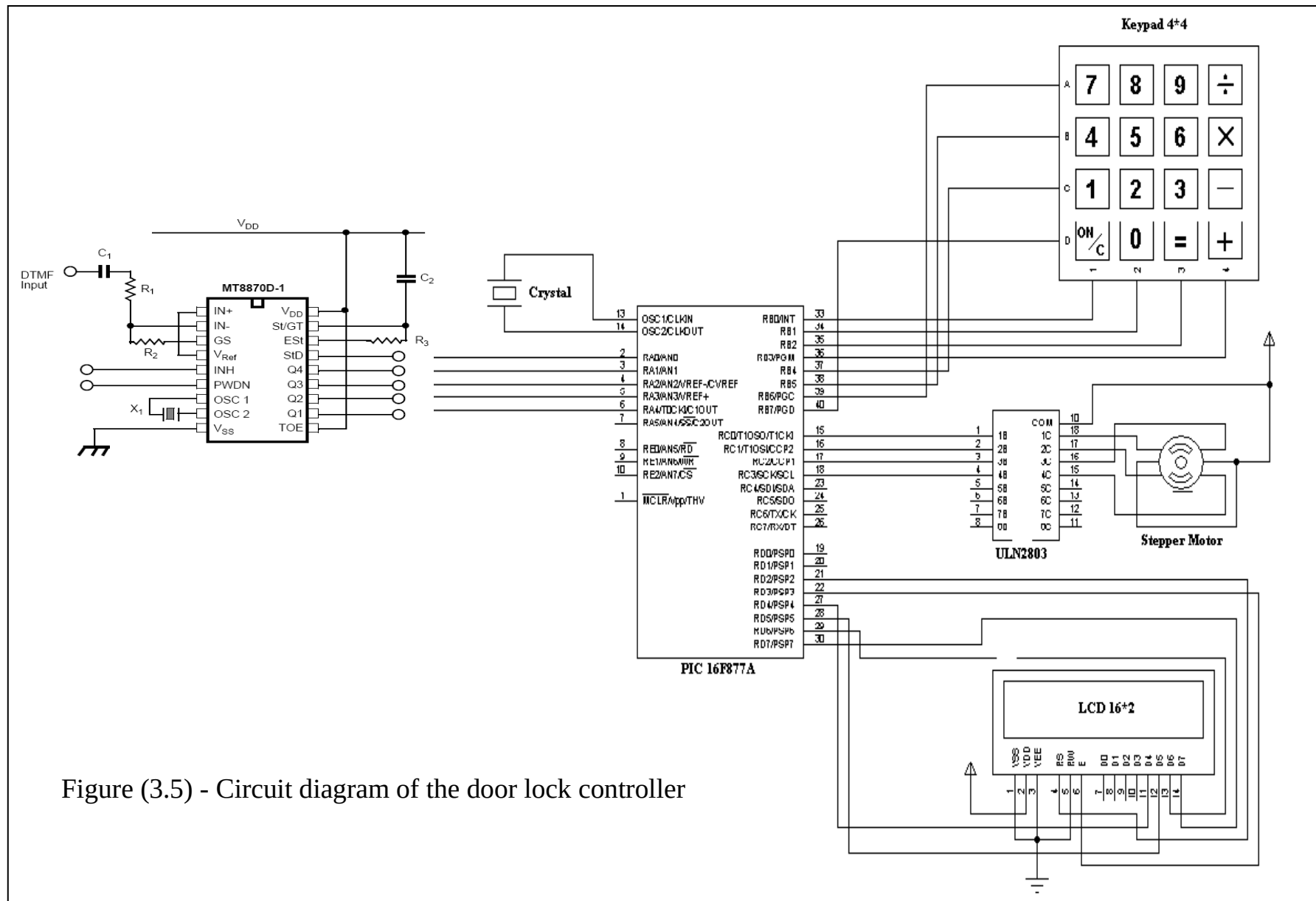


Figure (3.5) - Circuit diagram of the door lock controller

3.5 k150 Programmer

The USB PIC K150 microcontroller programmer is a low-cost high-performance PIC programmer, support most popular PIC chip burning Write, read and other functions, use a high-speed USB communication, ultra-fast programming, programming quality is stable and reliable [9].

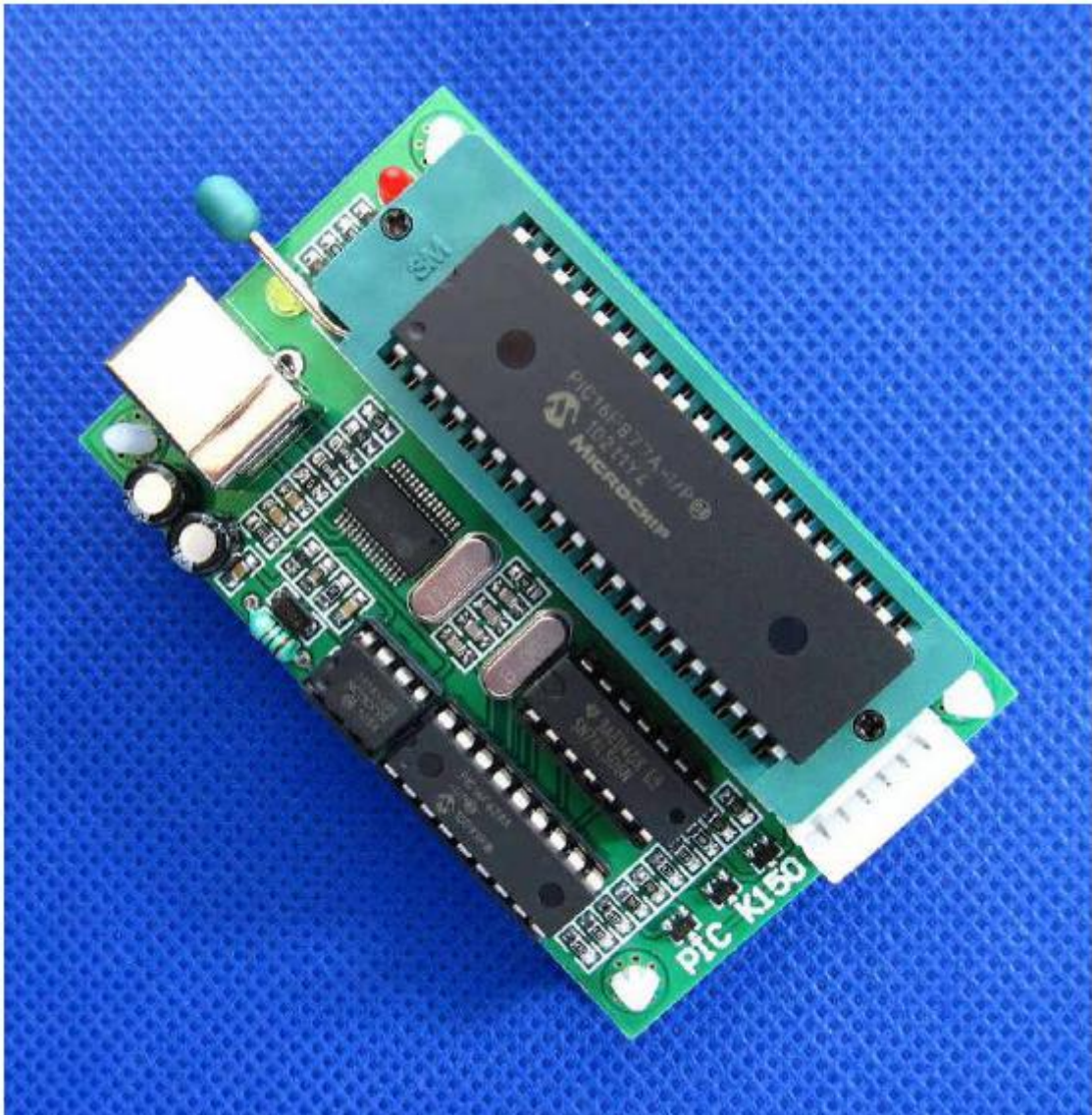


Figure (3.6) - PIC k150 programmer

3.6 Dual Tone Multiple Frequency (DTMF)

Dual Tone Multi Frequency signaling is used for telecommunication signaling over analog telephone lines in the voice-frequency band between telephone handsets and other communications devices and the switching center [10].

Dual Tone Multi-Frequency, or DTMF, is a method for instructing a telephone switching system of the telephone number to be dialed, or to issue commands to switching systems or related telephony equipment [10].

The MT8870 is a complete DTMF receiver integrating both the band split filter and digital decoder functions. The filter section uses switched capacitor techniques for high and low group filters, the decoder uses digital counting techniques to detect and decode all 16 DTMF tone-pairs into a 4-bit code [10].

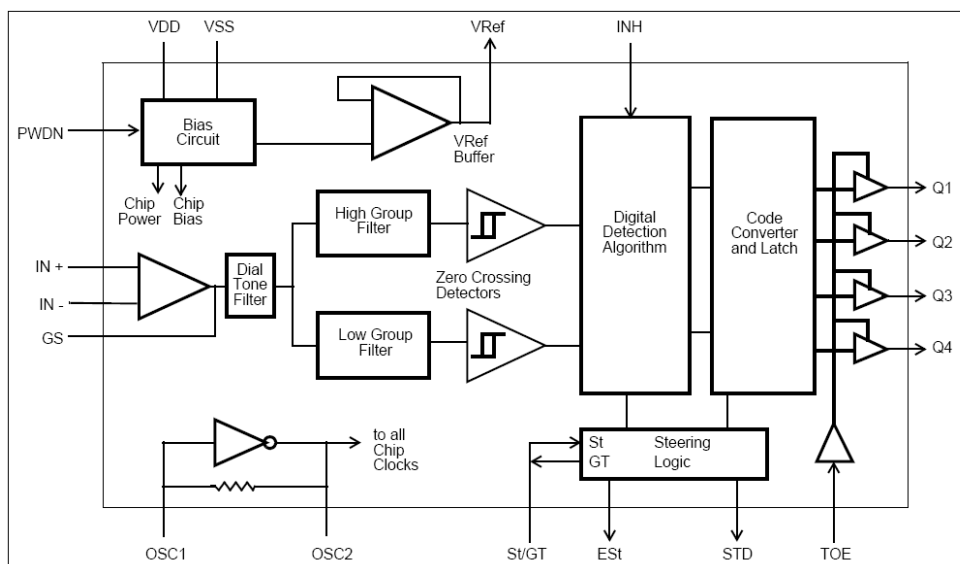


Figure (3.7) - Functional Block Diagram of MT887

External component count is minimized by on chip provision of a differential input amplifier, clock oscillator and latched three-state bus interface.

The MT8870 provides full DTMF receiver capability by integrating both the band-split filter and digital decoder functions into a single 18-pin. The filter section uses a switched capacitor technique for both high and low group filters and dial tone rejection [10].

All types of the MT8870 series use digital counting techniques to detect and decode all the 16 DTMF tone pairs into a 4-bit code output. The built-in dial tone rejection circuit eliminates the need for pre-filtering. When the input signal given at pin 2 (IN) in single-ended input configuration is recognized to be effective, the correct 4-bit decode signal of the DTMF tone is transferred to Q1 (pin 11), Q2 (pin 12), Q3 (pin 13), Q4 (pin 14) outputs of the DTMF decoder (IC) are connected to port pins of microcontroller [10].

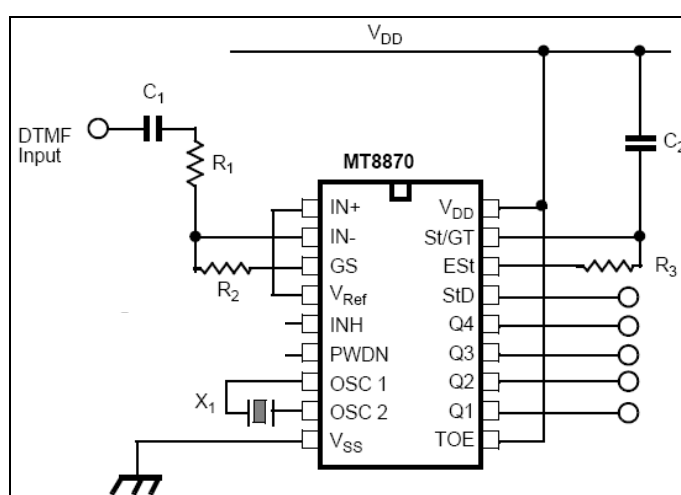


Figure (3.8) – MT8870 Single-Ended Input Configuration

DTMF keypad is laid out in a 4×4 matrix, with each row representing a low frequency, and each column representing a high frequency. Pressing a single key (such as ‘1’) will send a sinusoidal

tone for each of the two frequencies (697 and 1209 hertz (Hz)). The original keypads had levers inside, so each button activated two contacts. The multiple tones are the reason for calling the system multi frequency. These tones are then decoded by the switching center to determine which key was pressed [10].

Table (3.1) - DTMF keypad frequencies

(with sound clips)				
	1209 Hz	1336 Hz	1477 Hz	1633 Hz
697 Hz	<u>1</u>	<u>2</u>	<u>3</u>	<u>A</u>
770 Hz	<u>4</u>	<u>5</u>	<u>6</u>	<u>B</u>
852 Hz	<u>7</u>	<u>8</u>	<u>9</u>	<u>C</u>
941 Hz	<u>*</u>	<u>0</u>	<u>#</u>	<u>D</u>

DTMF MT8870 is an IC which converts the numbers at any mobile to the binary number and each number has low and high frequency [10].

Table (3.2) - Digit coding

F _{LOW}	F _{HIGH}	KEY	TOE	Q ₄	Q ₃	Q ₂	Q ₁
697	1209	1	H	0	0	0	1
697	1336	2	H	0	0	1	0
697	1477	3	H	0	0	1	1
770	1209	4	H	0	1	0	0
770	1336	5	H	0	1	0	1
770	1477	6	H	0	1	1	0
852	1209	7	H	0	1	1	1
852	1336	8	H	1	0	0	0
852	1477	9	H	1	0	0	1
941	1209	0	H	1	0	1	0
941	1336	.	H	1	0	1	1
941	1477	#	H	1	1	0	0
697	1633	A	H	1	1	0	1
770	1633	B	H	1	1	1	0
852	1633	C	H	1	1	1	1
941	1633	D	H	0	0	0	0

3.7 Stepper Motor

As the name implies the stepper motor moves in distinct steps during its rotation. Each of these steps is defined by a Step Angle. In the example above you may notice that there are 4 distinct steps for the rotor to make a complete 360 degree rotation. This defines the steep angle at 90 degrees [11].

We can say that a stepper motor is actually a digital motor. This characteristic makes it very suitable for digital interfaces such as with a microcontroller [11].

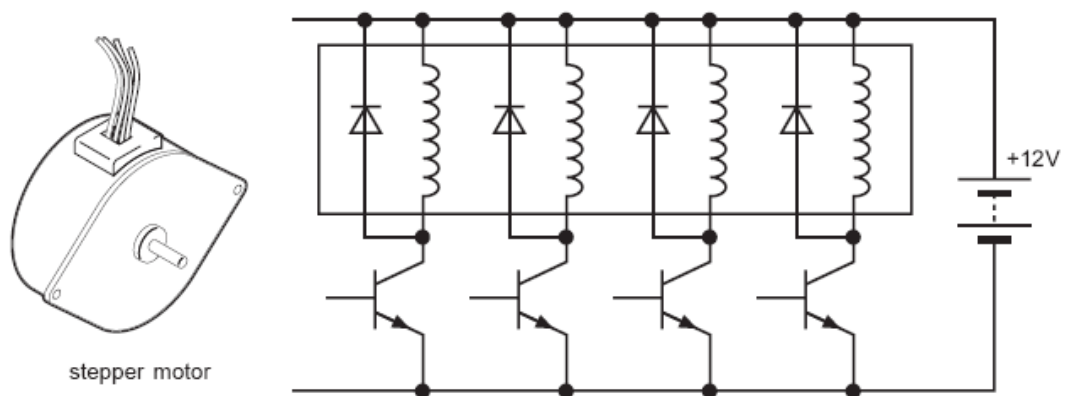


Figure (3.9) – Stepper motor

As the stepper motor operates at 12V, the standard transistor circuit is required to switch each coil. As the coils create a back EMF when switched off, a suppression diode on each coil is also required [11].

3.8.1 Motor Drive (ULN2803) Interface to PIC16F877A

Fortunately the Darlington driver IC ULN2803 can be used to provide both the NOT and Darlington driver circuits. It also contains

the back EMF suppression diodes so no external diodes are required. The complete circuit is shown next.

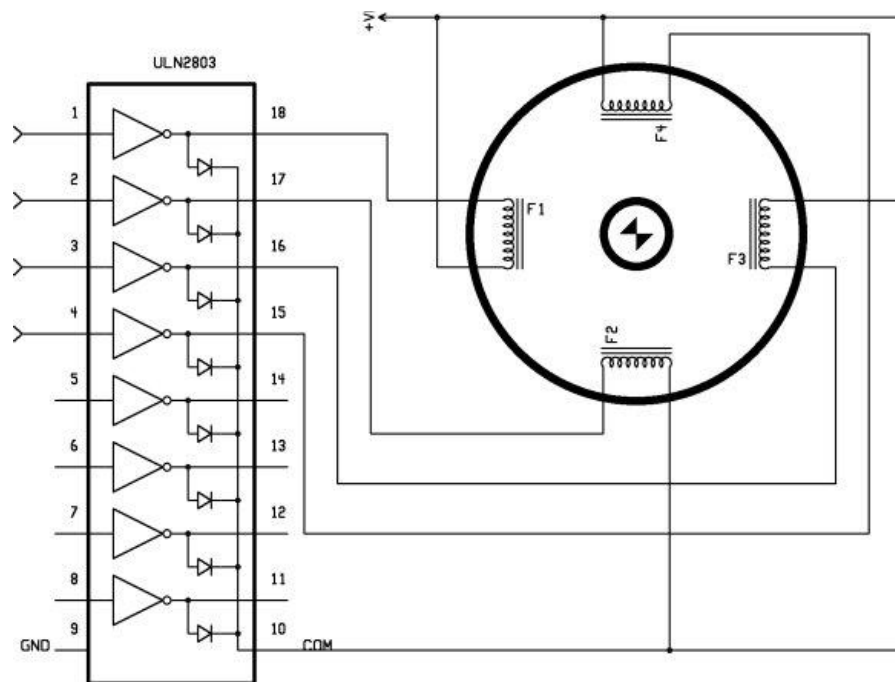


Figure (3.10) – ULN 2803 interface to stepper motor

Before programming, there is another pattern to notice in the stepping sequence. Look at this table, which show the four different steps required to make the motor turn [11].

Table (3.3) - Four different steps of stepper motor

Step	Coil ₁	Coil ₂	Coil ₃	Coil ₄
1.	1	0	1	0
2.	1	0	0	1
3.	0	1	0	1
4.	0	1	1	0
1.	1	0	1	0

Coil 2 is always the opposite (or logical NOT) of coil 1.

The same applies for coils 3 and 4. It is therefore possible to cut down the number of microcontroller pins required to just two by the use of two additional NOT gates [11].

3.8 Keypad Interface with Microcontroller

Matrix keypad is widely ~~use~~ in our daily life. Each switches connecting one row and column. So the combinations of rows and columns make up the 16 inputs [12]. Initially all the switches are open (not connected). When button pressed switch is now closed (connected). Then there is a connection between the row and column [12]. Scanning a keypad in PIC16F877A board in case of 4X4 matrix keypad both the ends of switches are connected to the port pin. Four rows and four columns, all sixteen switches have been interfaced using just eight lines [12].

Row lines (PORTD.0 – PORTD.3) and column lines (PORTD.4 to PORTD.7) connected directly by the port pins in PIC16F877A.

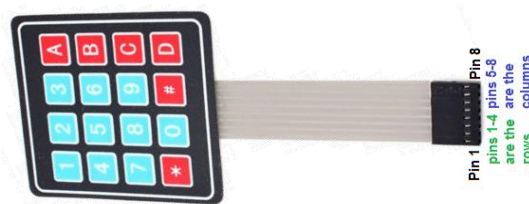


Figure (3.11) – Keypad 4*4

Table (3.4) – Connect keypad in PORTD

	4x4 Matrix Lines	PIC16F Lines
Rows	ROW-0	PORTD.0
	ROW-1	PORTD.1
	ROW-2	PORTD.2
	ROW-4	PORTD.3
Column	COLUMN-0	PORTD.4
	COLUMN-1	PORTD.5

	COLUMN-2	PORTD.6
	COLUMN-3	PORTD.7

3.9 Interfacing LCD with Microcontroller

Liquid Crystal Display (LCD) is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits [13].

A PIC Microcontroller can be easily made to communicate with LCD by using the built in Libraries of MikroC. Interfacing between PIC and LCD can be 4-bit or 8-bit [14].

In this project 4-bit mode is used 4-bit mode uses only 4 data lines, which are sending sequentially through data lines DB4 – DB7. The idea of 4-bit communication is to save as much pins that used to interface microcontroller with LCD. The 4-bit mode data transmission is most commonly used [14].

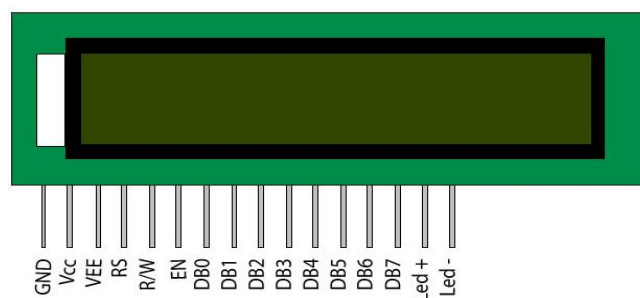


Figure (3.12) – LCD 16*2 Pin Diagram

Table (3.5) - LCD 16*2 Pin Description

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	V _{CC}
3	Contrast adjustment; through a variable resistor	V _{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
11	4-bit data pins	DB4
12		DB5
13		DB6
14		DB7
15	Backlight V _{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

Chapter Four

Results and discussions

Chapter Four

Results

Results and discussions

4.1 Simulation Results and discussions

The system design in proteus simulation is shown in Figure (4.1)

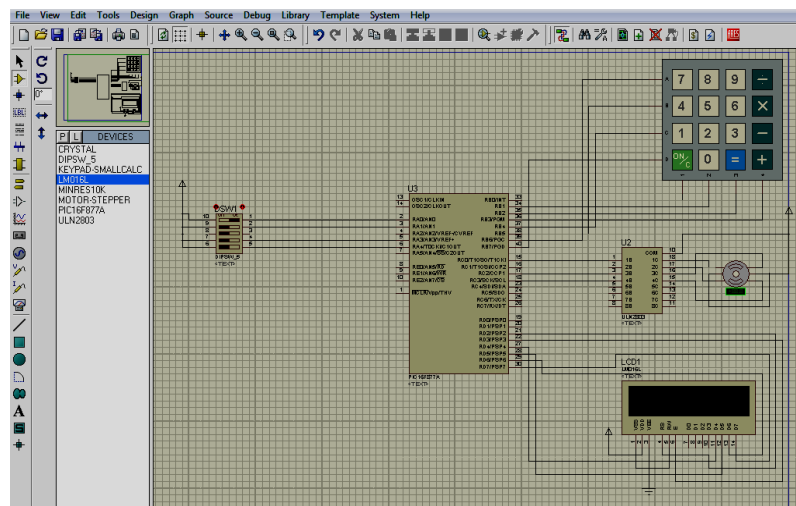


Figure (4.1) – System design in proteus program

In the initial state on the LCD display will show only a simple message indicating that it is expecting a password from keypad or mobile phone. This is shown in Figure (4.2)

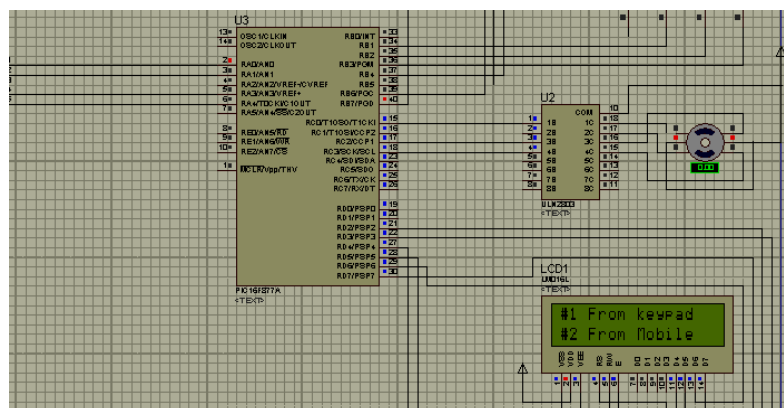


Figure (4.2) – Initial state of system

An authorized user would select option #1. The user is then prompted to enter the password from keypad as shown in Figure (4.3).

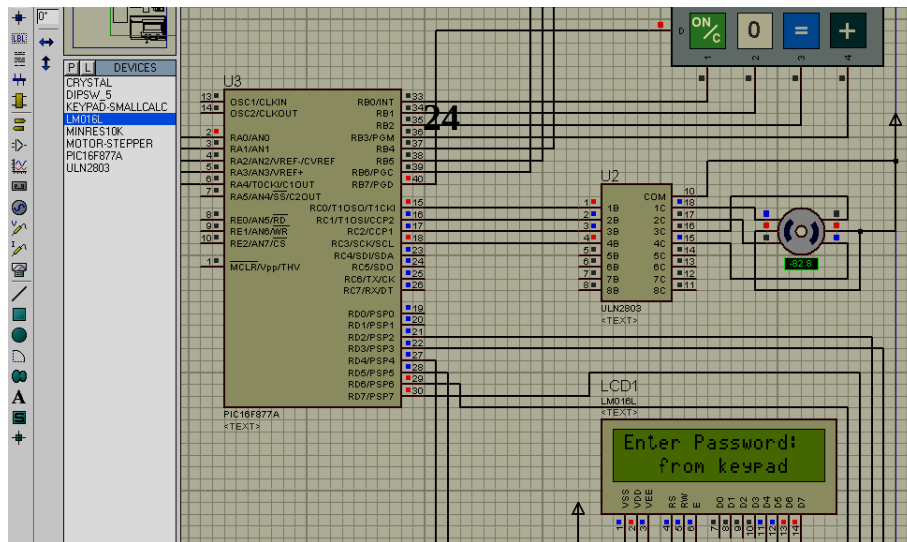


Figure (4.3) - System waiting password from keypad

For security purposes, the password is displayed as stars as it is the convention in such systems. This is illustrated in Figure (4.4).

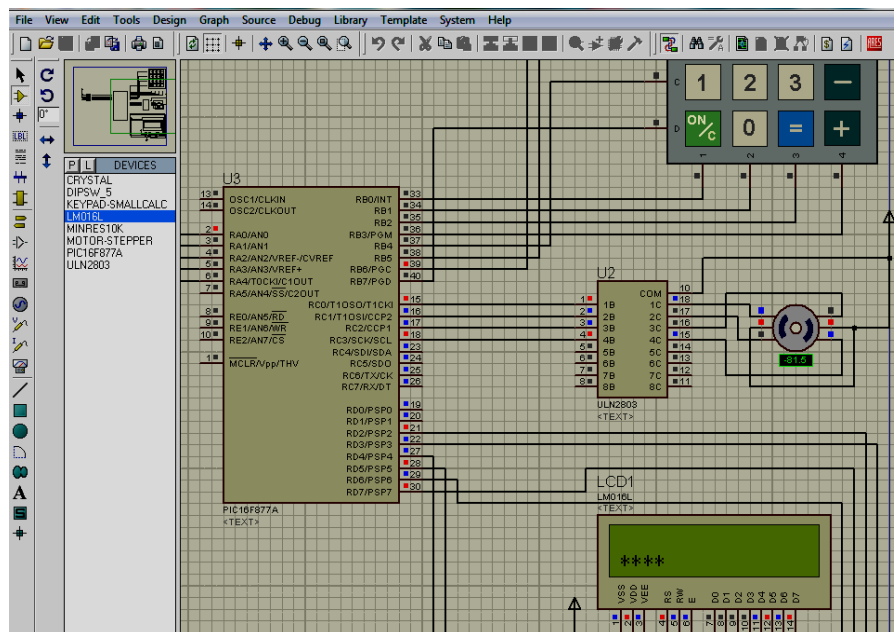


Figure (4.4) – Entering password to system from keypad

If the correct password is entered, the motor (door lock) will be activated in order to unlock the door. This is displayed “Lock Open” on the LCD as shown in Figure (4.5).

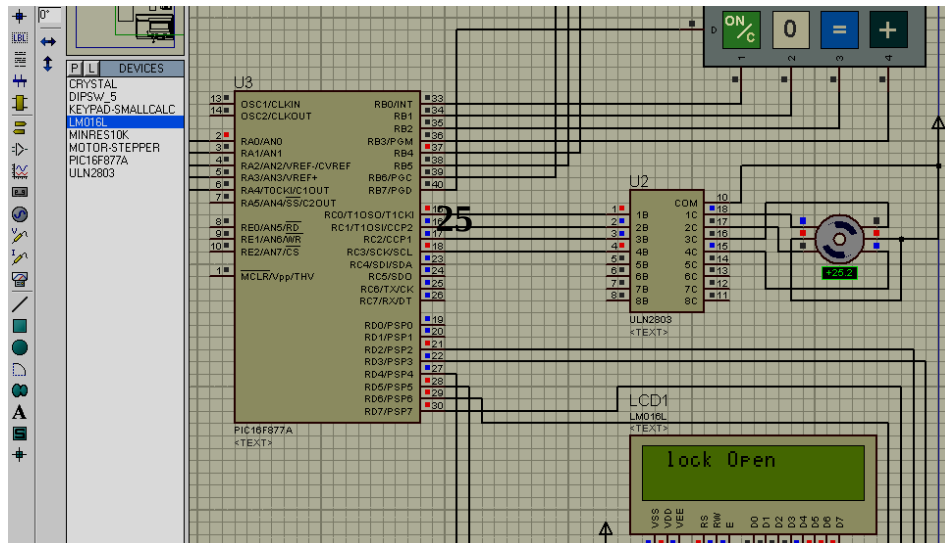


Figure (4.5) – Motor is activated in order to unlock the door

Then the door will close, the motor (door lock) will be activated in order to lock the door, this message will be display “Lock Close” on LCD as shown in Figure (4.6)

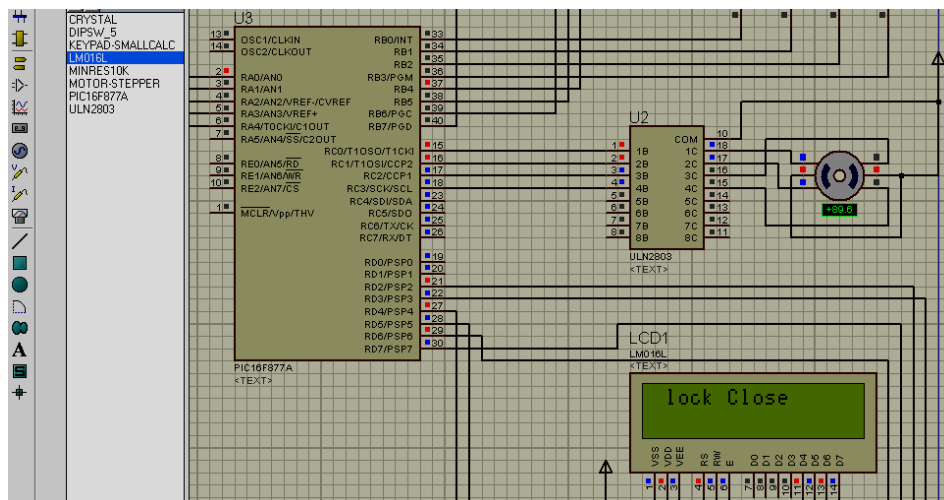


Figure (4.6) – Motor is activated in order to lock the door

If the user has no access to the premise, then he/she can contact the residents or someone who has access to the building. The idea is

that the door could be remotely unlocked by supplying the passwords over the phone using the DTMF functionality. This is activated by option #2 then it will display enter password from mobile as shown in Figure (4.7)

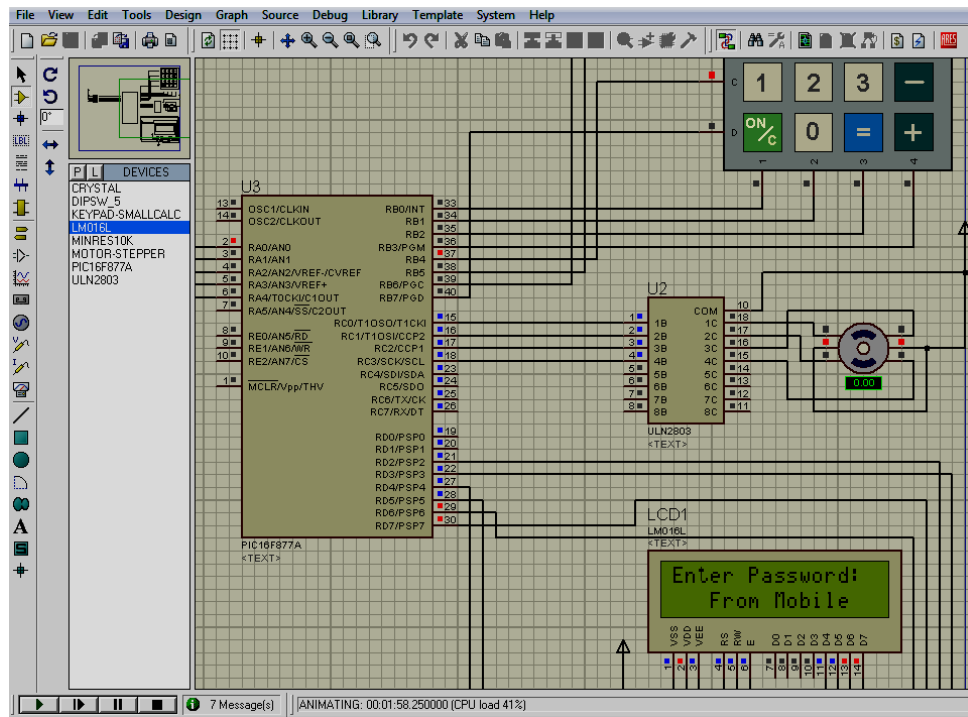


Figure (4.7) - System waiting password from mobile

So the owner will call the mobile phone that attached with system, he/she must set the mobile phone in the mode of auto answer when the headset is connect, in this mode the phone will auto answer after that the owner will enter the DTMF password remotely. The user requesting entrance will then be granted access to the premises. The password interring remotely will not be displayed on the LCD for security issue.

The user requesting entrance will then be granted access to the premises.

When door is turn to close it will press the reset button so the system will close the lock and LCD will display “Door locked”.

If the password is wrong when entered from keypad or remotely the LCD will display "sorry, wrong password" as shown in Figure (4.8).

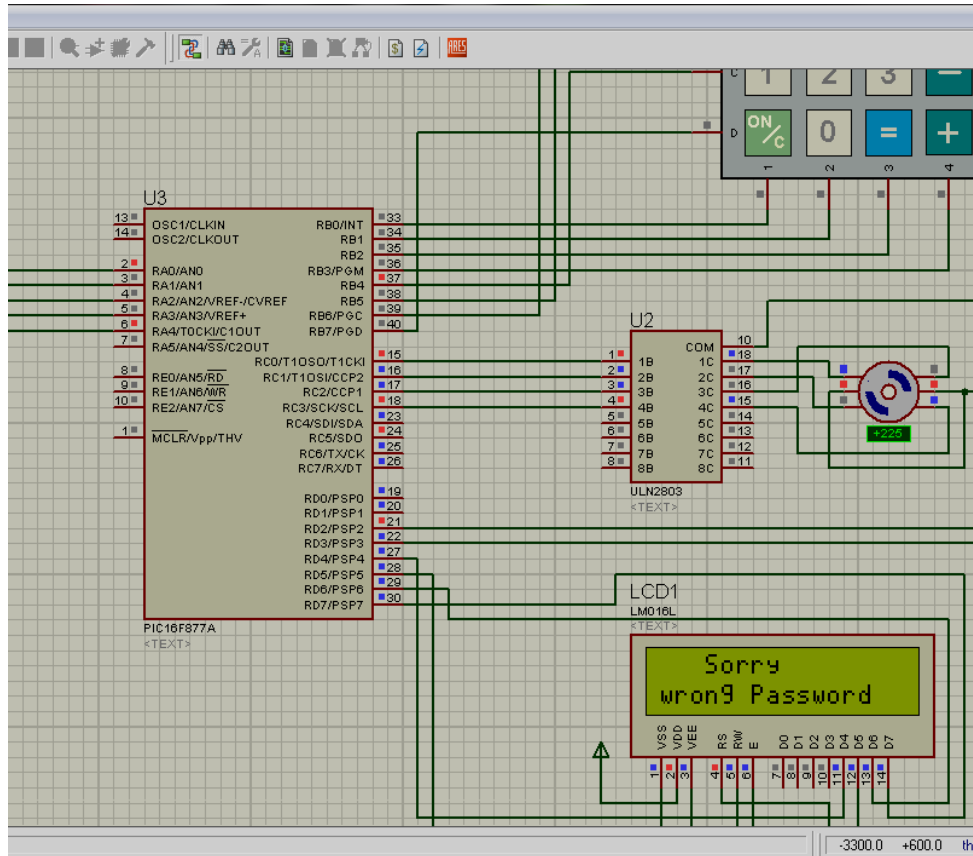


Figure (4.8) – System message when entered password is wrong

4.2 Results of Hardware construction

The system hardware design is shown in Figure (4.9).

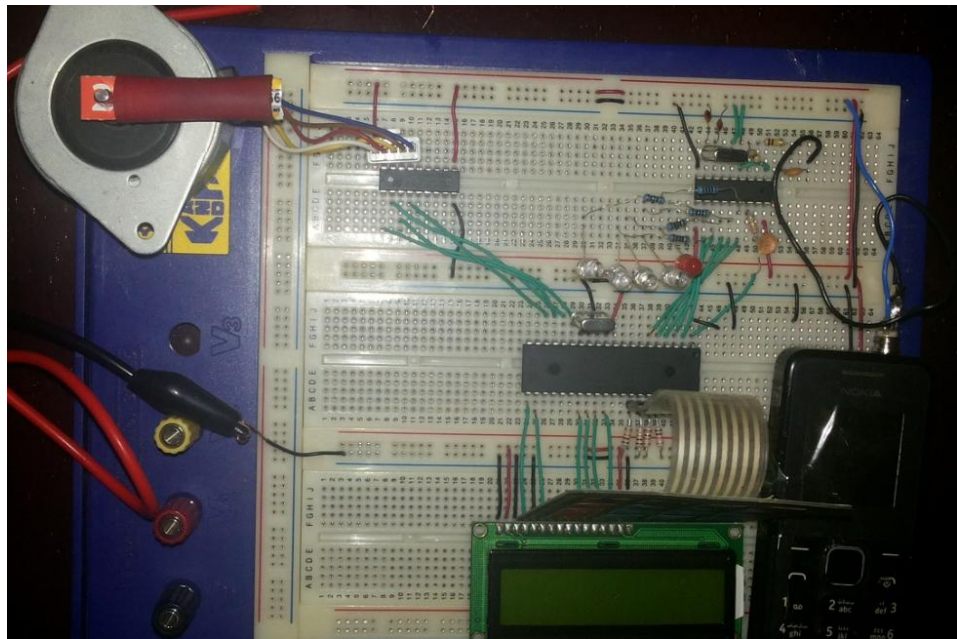


Figure (4.9) – System hardware design

Initially, the LCD will display two options; #1 is enter password from keypad, #2 is enter password from mobile phone as shown in Figure (4.10).

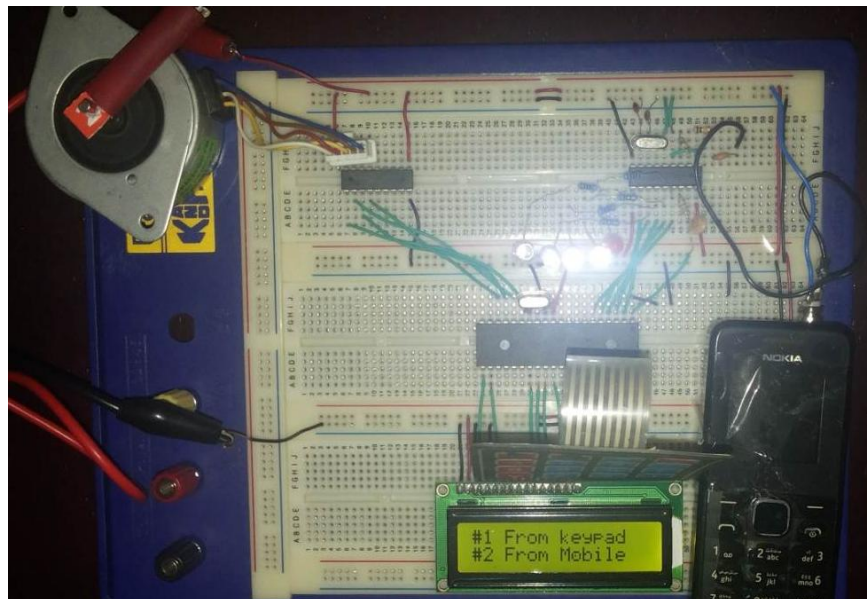


Figure (4.10) – Initial state of system

If #1 entered this message will be displayed on LCD “Enter password from keypad” as shown in Figure (4.11).

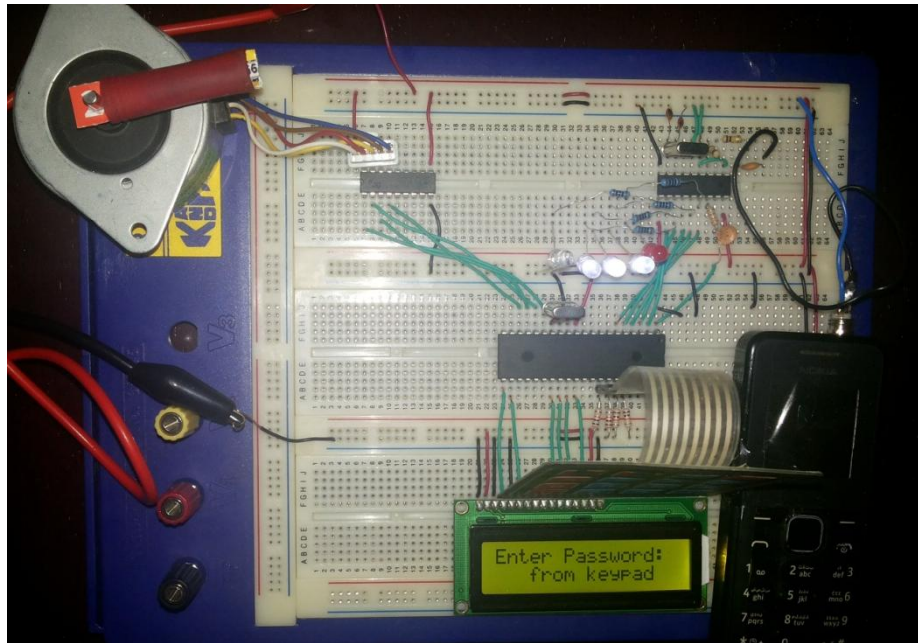


Figure (4.11) - System waiting password from keypad

For security purposes, the password is displayed as stars as it is the convention in such systems. This is illustrated in Figure (4.12).

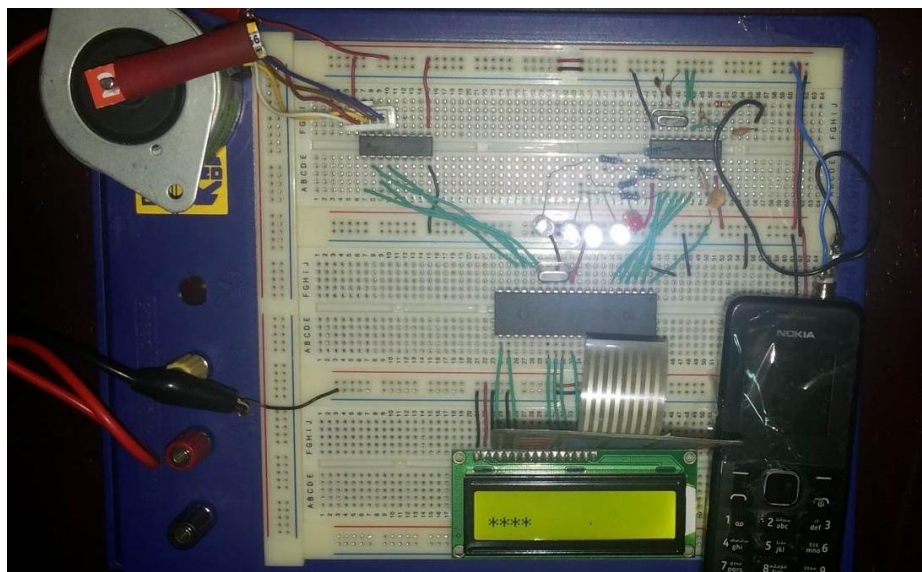


Figure (4.12) - Entering password to system from keypad

If the correct password is entered, the motor (door lock) will be activated in order to unlock the door. This is display “Lock Open” on the LCD as shown in Figure (4.13).

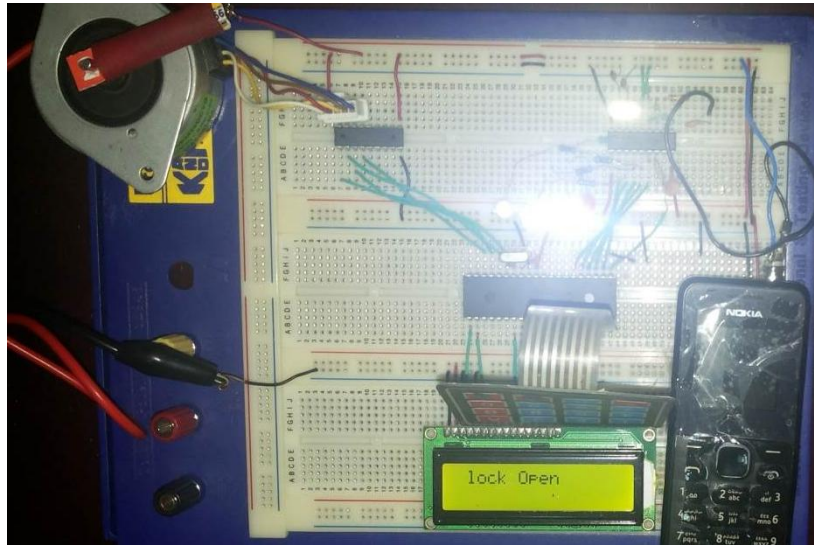


Figure (4.13) – Motor is activated in order to unlock the door

Then the door will close, the motor (door lock) will be activated in order to lock the door, this message will be display “Lock Close” on LCD as shown in Figure (4.14).

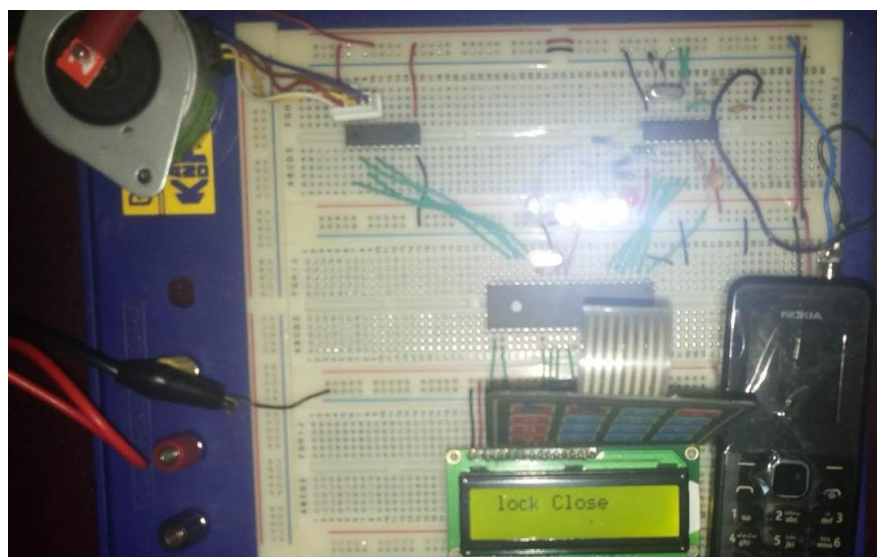


Figure (4.14) – Motor is activated in order to lock the door

If the user has no access to the premise, then he/she can contact the residents or someone who has access to the building. The idea is

that the door could be remotely unlocked by supplying the passwords over the phone using the DTMF functionality. This is activated by option #2 then it will display enter password from mobile as shown in Figure (4.15).

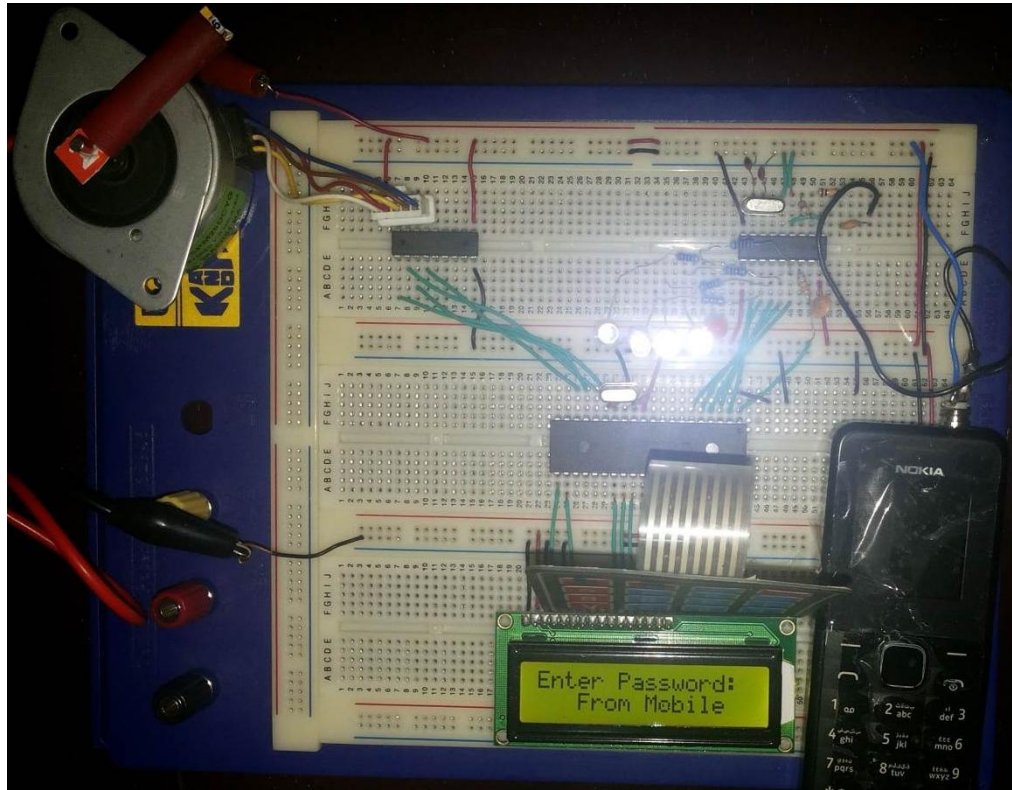


Figure (4.15) - System waiting password from mobile

So the owner will call the mobile phone that attached with system, he must set the mobile phone in the mode of auto answer when the headset is connect, in this mode the phone will auto answer after that the owner will enter the DTMF password remotely. The user requesting entrance will then be granted access to the premises. The password interring remotely will not be displayed on the LCD for security issue so the message that display on the LCD is Lock open.

When door is turn to close it will press the reset button so the system will close the lock and LCD will display “Door close”.

If the password is wrong when entered from keypad or remotely the LCD will display sorry wrong password as shown in Figure (4.16).

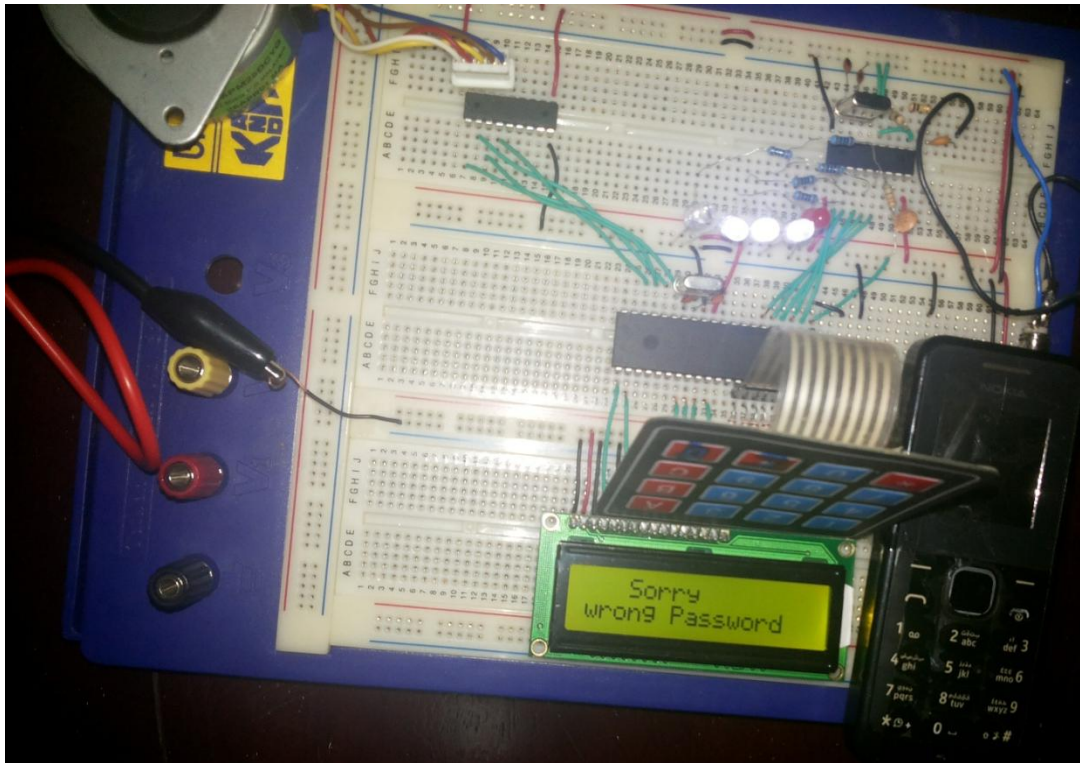


Figure (4.16) – System message when entered password is wrong



Figure (4.17) - Overall system and desired outputs.

Chapter Five

Conclusion and Recommendations

Chapter Five

Conclusions and Recommendations

5.1 Conclusions

This thesis has presented a low cost door lock system. Comparing to other biometrics locks that are based on different authentication method such as fingerprint and eye blinking detection, this lock has the advantage on cost basis. At the same time, it provides a reasonably safe access control mechanism.

This system is suitable for most outdoor security protection due to the fact that it has high discriminative capability during operation and they are fairly low cost useful system.

5.2 Recommendations

Instead of using the keypad build on the access point to start remote access which may cause some limitation to this system, the system may be directly accessed remotely to be more useful and practical.

The system could be expanded by integrating a call system with the present system. It could be simplified to allow the system to directly call the owner of the password from the access point. This removes the requirement that the person requesting access to have a mobile phone. The proposed modifications to the system can be developed with minimal costs and with relatively low operational

costs. The system requires high degrees of security, an example when children try to gain access to the home when no one is available at home.

Some feedback can be added to those who open door remotely about the status of the access point especially when kids access the entry point. Different types of alarms can be added to alert the occupants of the premises when the access point is open or someone tries to be gain access.

References

References

- [1] Raj Jain, A Survey of Biometrics Security Systems, <http://www.cse.wustl.edu/~jain/cse571-11/ftp/biomet/index.html>, accessed on 7 March 2014.
- [2] Rachit Saini Jerry Shim Qi Zhao, alternative house security system, in March 2014. <https://courses.engr.illinois.edu/ece445/projects.asp?term=120128>, accessed on 19 April 2014.
- [3] Then Dao Hui “Microcontroller-Based Lock Using Color Security Code, in June 2013, <http://www.scribd.com/doc/188071886/Microcontroller-based-Lock-Using-Colour-Security-Code#scribd>, accessed on 25 April 2014.
- [4] Sadeque Reza Khan, Office Access Control System (OACS), International Journal of Embedded Systems and Applications (IJESA), June 2012. <http://arnetminer.org/publication/development-of-low-cost-private-office-access-control-system-oacs-3594050.html>, accessed on 25 February 2014.
- [5] Dogan Ibrahim, PIC BASIC Projects 30 Projects Using PIC BASIC and PIC BASIC PRO, Linacre House, <http://elsevier.com/locate/permissions>, accessed on 25 February 2014.
- [6] Martin Bates, introduction to Microelectronic system The PIC16F877A Microcontroller system security, Elsevier / Newness, October 2000. <http://pic-microcontroller.com/pic-microcontrollers-an-introduction-to-microelectronics-by-martin-bates-e-book>, accessed on 15 March 2014.
- [7] Proteus software, <http://geniusdevils.com/2013/03/what-is-proteus-software/>, accessed on 20 March 2014.
- [8] MikroC, http://www.mikroe.com/download/eng/documents/compiler_s/mikroc/pro/pic/help/introduction_to_mikroc_pro_for_pic.html accessed on 20 March 2014.
- [9] Manual: “User Manual – PIC K150 Programmer” www.gie.com.my, accessed on 22 March 2014.

[10] Application Note: MSAN-108. Applications of the MT8870 integrated DTMF Receiver. www.zarlink.com accessed on 18 May 2014.

[11] Stepper Motor, http://en.wikipedia.org/wiki/Stepper_motor accessed on 15 June 2014.

[12] Keypad, <https://iamzxlee.wordpress.com/2013/07/24/4x4-matrix-keypad/> accessed on 6 November 2014.

[13] Data Sheet: LCD 16x2.pdf, Electronics Reference Design Library, <http://www.engineersgarage.com/electronic-components/16x2-lcd-module-datasheet> accessed on 8 November 2014.

[14] LCD interfacing with PIC Microcontroller, by Ligo George, <http://electrosome.com/lcd-pic-interfacing> accessed on 8 November 2014.

Appendices

Appendix A

Project code

```
kp;
char code1[16] ;
char Default_Password[5]={'1', '1', '1', '1','1'};
int i = 0, oldstate;
int Compare_Password();
char get_key();
char Temp_Password_DTMF[5];
int k=0;

//keypad module connections
char keypadPort at PORTB;
//end keypad module connections

//lcd module connections
sbit LCD_RS at RD2_bit;
sbit LCD_EN at RD3_bit;
sbit LCD_D4 at RD4_bit;
sbit LCD_D5 at RD5_bit;
sbit LCD_D6 at RD6_bit;
sbit LCD_D7 at RD7_bit;
sbit LCD_RS_Direction at TRISD2_bit;
sbit LCD_EN_Direction at TRISD3_bit;
sbit LCD_D4_Direction at TRISD4_bit;
sbit LCD_D5_Direction at TRISD5_bit;
sbit LCD_D6_Direction at TRISD6_bit;
sbit LCD_D7_Direction at TRISD7_bit;

void Open_Door()
{
    Lcd_Cmd(_LCD_CLEAR);
    Lcd_Out(1, 2,"lock Open");
```

```
PORTC=0x03;
Delay_ms(500);
PORTC=0x06;
Delay_ms(500);
PORTC=0x0C;
Delay_ms(500);
PORTC=0x09;
Delay_ms(500);
PORTC=0x03;
Delay_ms(500);
PORTC=0x06;
Delay_ms(500);
PORTC=0x0C;
Delay_ms(500);
PORTC=0x09;
Delay_ms(500);

LCD_Cmd(_LCD_CLEAR);
Lcd_out(1, 2,"lock Close");
```

```
PORTC=0x0C;
Delay_ms(500);
PORTC=0x06;
Delay_ms(500);
PORTC=0x03;
Delay_ms(500);
PORTC=0x09;
Delay_ms(500);
Delay_ms(500);
PORTC=0x06;
Delay_ms(500);
PORTC=0x03;
Delay_ms(500);
PORTC=0x09;
Delay_ms(500);
return;
```

```
}
```

```
void code_enter(){
```

```

//keypad_init();
oldstate = 0;
kp = 0;    //Reset key code variable
//wait for key to be pressed and released
do
//kp = Keypad_Key_Press();    // store key code in kp variable
kp = Keypad_Key_Click();    // store key code in kp variable
while (!kp);
//prepare value for output, transform key to it's ASCII value

switch (kp){
    case 1: kp = 49; break; // 1
    case 2: kp = 50; break; // 2
    case 3: kp = 51; break; // 3
    //case 4: kp = 65; break; // A for 4x4 pad
    case 5: kp = 52; break; // 4
    case 6: kp = 53; break; // 5
    case 7: kp = 54; break; // 6
    //case 8: kp = 66; break; // B for 4x4 pad
    case 9: kp = 55; break; // 7
    case 10: kp = 56; break; // 8
    case 11: kp = 57; break; // 9
    //case 12: kp = 67; break; // C for 4x4 pad
    case 13: kp = 42; break; // *
    case 14: kp = 48; break; // 0
    case 15: kp = 35; break; // #
    //case 16: kp = 68; break; // D for 4x4 pad
}
if(i==0)
{
    Lcd_Cmd(_LCD_CLEAR);
}
code1[i] = kp;
//Lcd_Chr(2, i+1, code1[i]);    //Print key ASCII value on Lcd
Lcd_Chr(2, i+1, '*');    //Print key ASCII value on Lcd
i++;
}

void main(){
//int kp;

```

```

Keypad_Init();          // Initialize Keypad
TRISC = 0x00;
PORTC = 0x00;
TRISD = 0x00;
PORTD = 0x00;
ADCON1 = 0X07;          //A/D converter
PORTA = 0XFF;
TRISA = 0XFF;
PORTB = 0XFF;
TRISB = 0XFF;
Lcd_Init();              // Initialize LCD
Lcd_Cmd(_LCD_CLEAR);     // Clear display
Lcd_Cmd(_LCD_CURSOR_OFF); // Cursor off

```

```
do {
```

```

    Lcd_Out(1, 1, "#1 From keypad");
    Lcd_Out(2, 1, "#2 From Mobile");
    Lcd_Cmd(_LCD_CURSOR_OFF);
        kp= Keypad_Key_Click();
        if (kp==1)
        {
            Lcd_Cmd(_LCD_CLEAR);    // clear display
            Lcd_Out(1, 1, "Enter Password:");
            Lcd_Out(2, 4, "from keypad");
            Lcd_Cmd(_LCD_CURSOR_OFF);

            i=0;
            code_enter();
            code_enter();
            code_enter();
            code_enter();
            code_enter();
            Compare_Password();
        }

        if (kp==2)
        {
            Lcd_Cmd(_LCD_CLEAR);    // clear display

```

```

        Lcd_Out(1, 1,"Enter Password:");
        Lcd_Out(2, 4,"From Mobile");
        Lcd_Cmd(_LCD_CURSOR_OFF);
        k=0;
        for(k=0;k<5;k++){
            Temp_Password_DTMF[k]=get_key();
            Compare_Password();
        }
    }
    while(1);}

//int Compare_Password(char *password)
int Compare_Password()
{
    int j=0;

    char Temp_Password1[5];
    for(j=0;j<5;j++)
    {
        Temp_Password1[j]=code1[j];
    }
    while (1)
    {
        int f=1;
        int c;
        int f2=1;
        int c1;
        for(c=0;c<5;c++)

            if ((code1[c]!=Default_Password[c]) )
                f=0;

        for(c1=0;c1<5;c1++)

            if(Temp_Password_DTMF[c1]!=Default_Password[c1])
                f2=0;
            if(f==1 || f2==1)
            {
                Open_Door();
                break;
            }
    }
}

```

```

    }
    else
    {
        Lcd_Cmd(_LCD_CLEAR);
        Lcd_Out(1, 4, "Sorry");
        Lcd_Out(2, 1, "wrong Password ");
        delay_ms(2000);
        Lcd_Cmd(_LCD_CLEAR);
        return;
    }
}

char get_key()
{
    while (1)
    {

        if (PORTa.f4==0)
        while (1)
        {

            if (PORTa.f0==1 && PORTa.f1==0 && PORTa.f2==0 &&
PORTa.f3==0)          // if the INPUT = "1"
            {
                return '1';
            }

            if (PORTa.f0==0 && PORTa.f1==1 && PORTa.f2==0 &&
PORTa.f3==0)          // if the INPUT = "2"
            {
                return '2';
            }

            if (PORTa.f0==1 && PORTa.f1==1 && PORTa.f2==0 &&
PORTa.f3==0)          // if the INPUT = "3"
            {

                return '3';
            }

```

```
        if (PORTa.f0==0 && PORTa.f1==0 && PORTa.f2==1 &&
PORTa.f3==0)          // if the INPUT = "4"
        {
            return '4';
        }
```

```
        if (PORTa.f0==1 && PORTa.f1==0 && PORTa.f2==1 &&
PORTa.f3==0)          // if the INPUT = "5"
        {
            return '5';
        }
```

```
        if (PORTa.f0==0 && PORTa.f1==1 && PORTa.f2==1 &&
PORTa.f3==0)          // if the INPUT = "6"
        {
            return '6';
        }
```

```
        if (PORTa.f0==1 && PORTa.f1==1 && PORTa.f2==1 &&
PORTa.f3==0)          // if the INPUT = "7"
        {
            return '7';
        }
```

```
        if (PORTa.f0==0 && PORTa.f1==0 && PORTa.f2==0 &&
PORTa.f3==1)          // if the INPUT = "8"
        {
            return '8';
        }
```

```
        if (PORTa.f0==1 && PORTa.f1==0 && PORTa.f2==0 &&
PORTa.f3==1)          // if the INPUT = "9"
        {
            return '9';
        }
```

```
        if (PORTa.f0==0 && PORTa.f1==0 && PORTa.f2==1 &&
PORTa.f3==1)          // if the INPUT = "#"
        {
            return '#';
        }
```

```
    }

    if (PORTa.f0==1 && PORTa.f1==1 && PORTa.f2==0 &&
PORTa.f3==1)          // if the INPUT = "*"
    {
        return '*';
    }

    if (PORTa.f0==0 && PORTa.f1==1 && PORTa.f2==0 &&
PORTa.f3==1)          // if the INPUT = "0"
    {
        return '0';
    }

    }
    }
}
```

Appendix B

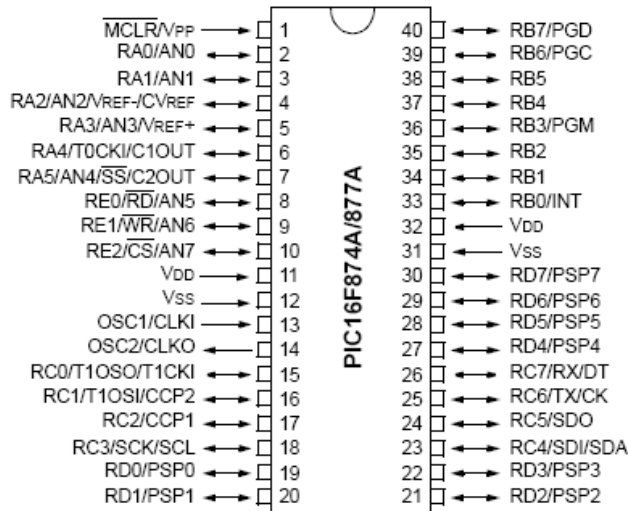
PIC 16F877A Data Sheet



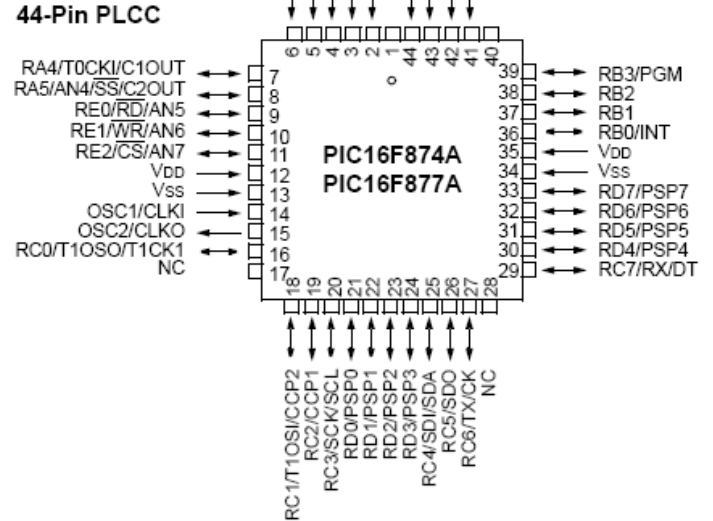
PIC16F87XA Data Sheet

28/40/44-Pin Enhanced Flash
Microcontrollers

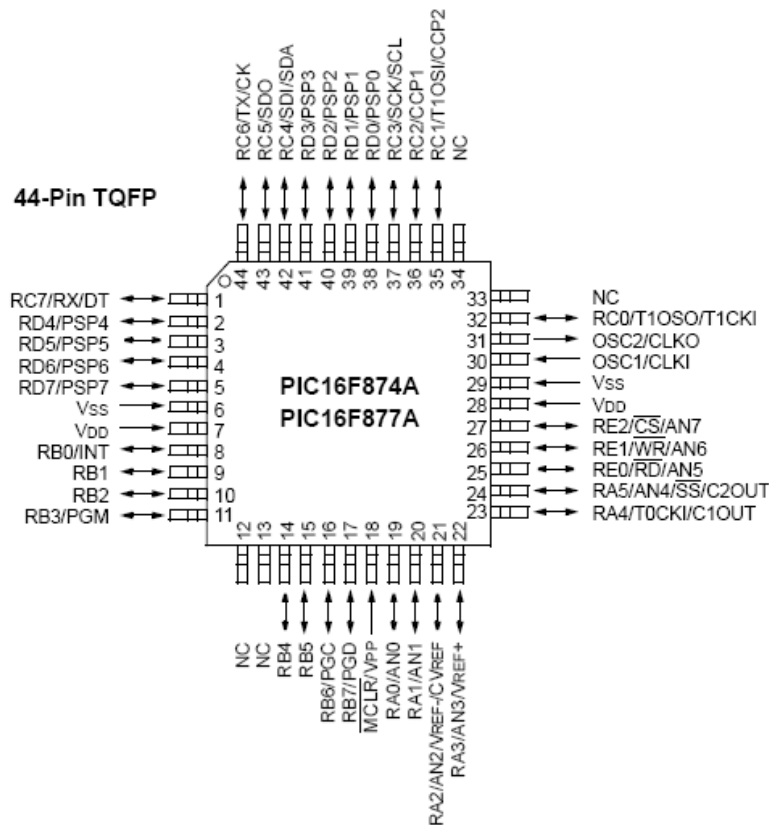
40-Pin PDIP



44-Pin PLCC

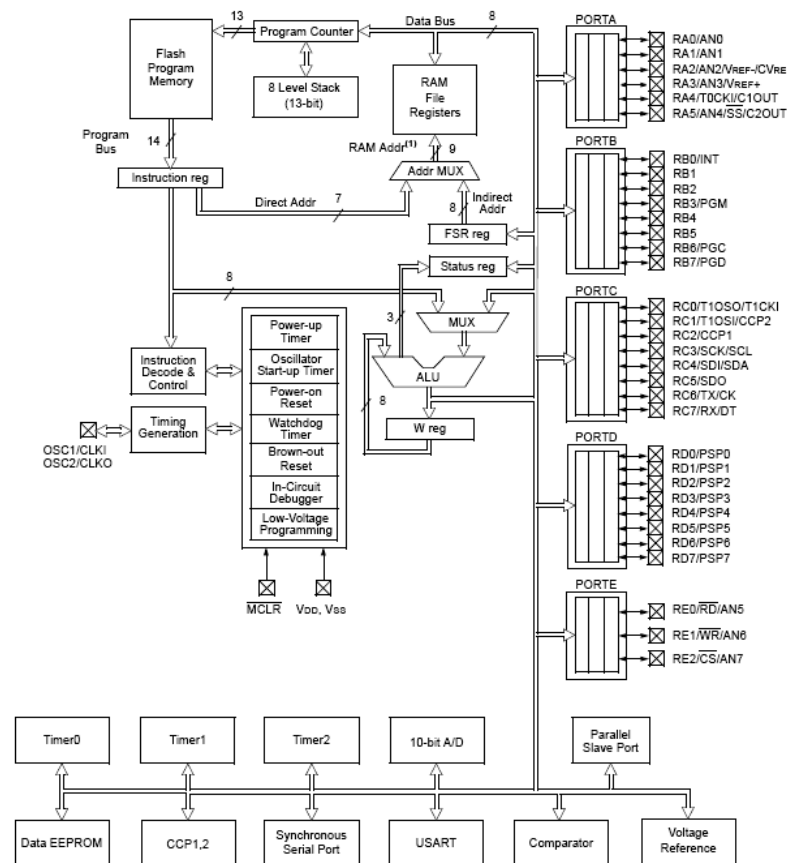


44-Pin TQFP



3.10 PIC 16F877A

PIC16F877A is 40 pins operating speed is 20 MHz, 200 ns instruction cycle, operating voltage is 4.0-5.5V, industrial temperature range (-40° to +85°C), 15 Interrupt Sources, 35 single-word instructions, All single-cycle instructions except for program branches (two-cycle), Flash Memory 14.3 Kbytes (8192 words), Data SRAM: 368 bytes, Data EEPROM: 256 bytes, Self-reprogrammable under software control, In-Circuit Serial Programming via two pins (5V), Watchdog Timer with on-chip RC oscillator, Programmable code protection, Power-saving Sleep mode, Selectable oscillator options, In-Circuit Debug via two pins, 33 I/O pins; 5 I/O ports.



PIC 16F877A Block Diagram

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKI OSC1 CLKI	13	14	30	32	I I	ST/CM OS(4)	Oscillator crystal or external clock input. Oscillator crystal input or external clock source input. ST buffer when configured in RC mode; otherwise CMOS. External clock source input. Always associated with pin function OSC1 (see OSC1/CLKI, OSC2/CLKO pins).
OSC2/CLKO OSC2 CLKO	14	15	31	33	O O	—	Oscillator crystal or clock output. Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode. In RC mode, OSC2 pin outputs CLKO, which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
MCLR/VPP MCLR VPP	1	2	18	18	I P	ST	Master Clear (input) or programming voltage (output). Master Clear (Reset) input. This pin is an active low Reset to the device. Programming voltage input.
RA0/AN0 RA0 AN0	2	3	19	19	I/O I	TTL	PORTA is a bidirectional I/O port. Digital I/O. Analog input 0.
RA1/AN1 RA1 AN1	3	4	20	20	I/O I	TTL	Digital I/O. Analog input 1.
RA2/AN2/VREF-/CVREF RA2 AN2 VREF- CVREF	4	5	21	21	I/O I I O	TTL	Digital I/O. Analog input 2. A/D reference voltage (Low) input. Comparator VREF output.
RA3/AN3/VREF+ RA3 AN3 VREF+	5	6	22	22	I/O I I	TTL	Digital I/O. Analog input 3. A/D reference voltage (High) input.
RA4/T0CKI/C1OUT RA4 T0CKI C1OUT	6	7	23	23	I/O I O	ST	Digital I/O – Open-drain when configured as output. Timer0 external clock input. Comparator 1 output.
RA5/AN4/SS/C2OUT RA5 AN4 SS C2OUT	7	8	24	24	I/O I I O	TTL	Digital I/O. Analog input 4. SPI slave select input. Comparator 2 output.
RB0/INT RB0 INT	33	36	8	9	I/O I	TTL/ST (1)	PORTB is a bidirectional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs. Digital I/O. External interrupt.
RB1	34	37	9	10	I/O	TTL	Digital I/O.
RB2	35	38	10	11	I/O	TTL	Digital I/O.
RB3/PGM RB3 PGM	36	39	11	12	I/O I	TTL	Digital I/O. Low-voltage ICSP programming enable pin.
RB4	37	41	14	14	I/O	TTL	Digital I/O.
RB5	38	42	15	15	I/O	TTL	Digital I/O.
RB6/PGC	39	43	16	16		TTL/ST (2)	
RB6 PGC					I/O I		Digital I/O. In-circuit debugger and ICSP programming clock.
RB7/PGD	40	44	17	17		TTL/ST	

RB7 PGD					I/O I/O	(2)	Digital I/O. In-circuit debugger and ICSP programming data.
RC0/T1OSO/T1CKI RC0 T1OSO T1CKI	15	16	32	34	I/O O I	ST	PORTC is a bidirectional I/O port. Digital I/O. Timer1 oscillator output. Timer1 external clock input.
RC1/T1OSI/CCP2 RC1 T1OSI CCP2	16	18	35	35	I/O I I/O	ST	Digital I/O. Timer1 oscillator input. Capture2 input, Compare2 output, PWM2 output.
RC2/CCP1 RC2 CCP1	17	19	36	36	I/O	ST	Digital I/O. Capture1 input, Compare1 output, PWM1 output.
RC3/SCK/SCL RC3 SCK SCL	18	20	37	37	I/O I/O I/O	ST	Digital I/O. Synchronous serial clock input/output for SPI mode. Synchronous serial clock input/output for I2C mode.
RC4/SDI/SDA RC4 SDI SDA	23	25	42	42	I/O I I/O	ST	Digital I/O. SPI data in. I2C data I/O.
RC5/SDO RC5 SDO	24	26	43	43	I/O O	ST	Digital I/O. SPI data out.
RC6/TX/CK RC6 TX CK	25	27	44	44	I/O O I/O	ST	Digital I/O. USART asynchronous transmit. USART1 synchronous clock.
RC7/RX/DT RC7 RX DT	26	29	1	1	I/O I I/O	ST	Digital I/O. USART asynchronous receive. USART synchronous data.
RD0/PSP0 RD0 PSP0	19	21	38	38	I/O I/O	ST/T TL ⁽³⁾	PORTD is a bidirectional I/O port or Parallel Slave Port when interfacing to a microprocessor bus. Digital I/O. Parallel Slave Port data
RD1/PSP1 RD1 PSP1	20	22	39	39	I/O I/O	ST/T TL ⁽³⁾	Digital I/O. Parallel Slave Port data
RD2/PSP2 RD2 PSP2	21	23	40	40	I/O I/O	ST/T TL ⁽³⁾	Digital I/O. Parallel Slave Port data.
RD3/PSP3 RD3 PSP3	22	24	41	41	I/O I/O	ST/T TL ⁽³⁾	Digital I/O. Parallel Slave Port data.
RD4/PSP4 RD4 PSP4	27	30	2	2	I/O I/O	ST/T TL ⁽³⁾	Digital I/O. Parallel Slave Port data.
RD5/PSP5 RD5 PSP5	28	31	3	3	I/O I/O	ST/T TL ⁽³⁾	Digital I/O. Parallel Slave Port data.
RD6/PSP6 RD6 PSP6	29	32	4	4	I/O I/O	ST/T TL ⁽³⁾	Digital I/O. Parallel Slave Port data.
RD7/PSP7 RD7 PSP7	30	33	5	5	I/O I/O	ST/T TL ⁽³⁾	Digital I/O. Parallel Slave Port data.
RE0/RD/AN5 RE0	8	9	25	25	I/O	ST/T TL ⁽³⁾	PORTE is a bidirectional I/O port. Digital I/O.
RD					I		Read control for Parallel Slave Port.
AN5					I		Analog input 5.

RE1/WR/AN6	9	10	26	26		ST/T TL ⁽³⁾	
RE1					I/O		Digital I/O.
WR					I		Write control for Parallel Slave Port.
AN6					I		Analog input 6.
RE2/CS/AN7	10	11	27	27		ST/T TL(3)	
RE2					I/O		Digital I/O.
CS					I		Chip select control for Parallel Slave Port.
AN7					I		Analog input 7.
VSS	12, 31	13, 34	6, 29	6, 30, 31	P	—	Ground reference for logic and I/O pins.
VDD	11, 32	12, 35	7, 28	7, 8, 28, 29	P	—	Positive supply for logic and I/O pins.
NC	—	1, 17, 28, 40	12,13, 33, 34	13	—	—	These pins are not internally connected. These pins should be left unconnected

Legend: I = input O = output I/O = input/output P = power

— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.

2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.

3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

Appendix C

ULN2803

TOSHIBA

ULN2803,04APG/AFWG

TOSHIBA Bipolar Digital Integrated Circuit Silicon Monolithic

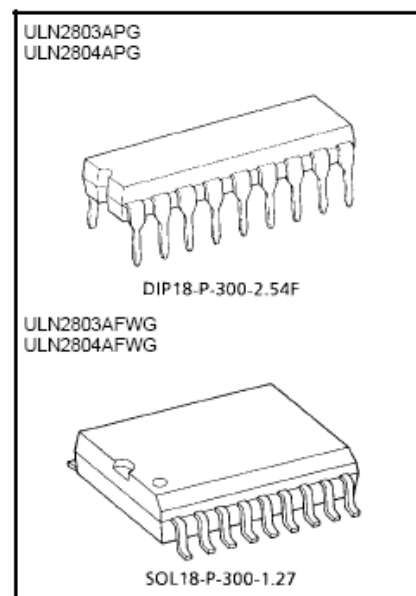
ULN2803APG,ULN2803AFWG,ULN2804APG,ULN2804AFWG (Manufactured by Toshiba Malaysia)

8ch Darlington Sink Driver

The ULN2803APG / AFWG Series are high-voltage, high-current darlington drivers comprised of eight NPN darlington pairs. All units feature integral clamp diodes for switching inductive loads. Applications include relay, hammer, lamp and display (LED) drivers.

Features

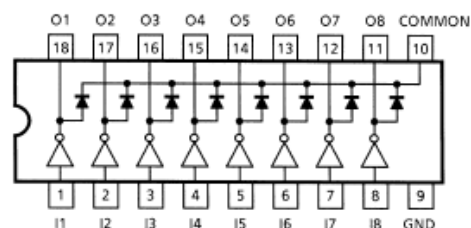
- Output current (single output)
500 mA (max)
- High sustaining voltage output
50 V (min)
- Output clamp diodes
- Inputs compatible with various types of logic.
- Package Type-APG : DIP-18pin
- Package Type-AFWG : SOL-18pin



Weight
DIP18-P-300-2.54F: 1.478 g (Typ.)
SOL18-P-300-1.27 : 0.48 g (Typ.)

Pin Connection (top view)

Type	Input Base Resistor	Designation
ULN2803APG / AFWG	2.7 k Ω	TTL, 5 V CMOS
ULN2804APG / AFWG	10.5 k Ω	6~15 V PMOS, CMOS



Appendix D

MT8870



MT8870D/MT8870D-1
ISO²-CMOS Integrated DTMF Receiver

Data Sheet

Features

May 2005

- Complete DTMF Receiver
- Low power consumption
- Internal gain setting amplifier
- Adjustable guard time
- Central office quality
- Power-down mode
- Inhibit mode
- Backward compatible with MT8870C/MT8870C-1

Applications

- Receiver system for British Telecom (BT) or CEPT Spec (MT8870D-1)
- Paging systems
- Repeater systems/mobile radio
- Credit card systems
- Remote control
- Personal computers
- Telephone answering machine

Ordering Information

MT8870DE	18 Pin PDIP	Tubes
MT8870DS	18 Pin SOIC	Tubes
MT8870DN	20 Pin SSOP	Tubes
MT8870DSR	18 Pin SOIC	Tape & Reel
MT8870DNR	20 Pin SSOP	Tape & Reel
MT8870DN1	20 Pin SSOP*	Tubes
MT8870DE1	18 Pin PDIP*	Tubes
MT8870DS1	18 Pin SOIC*	Tubes
MT8870DNR1	18 Pin SSOP*	Tape & Reel
MT8870DSR1	18 Pin SOIC*	Tape & Reel
MT8870DE1-1	18 Pin PDIP*	Tubes
MT8870DS1-1	18 Pin SOIC*	Tubes
MT8870DSR1-1	18 Pin SOIC*	Tape & Reel

*Pb Free Matte Tin

-40°C to +85°C

Description

The MT8870D/MT8870D-1 is a complete DTMF receiver integrating both the bandsplit filter and digital decoder functions. The filter section uses switched capacitor techniques for high and low group filters; the decoder uses digital counting techniques to detect and decode all 16 DTMF tone-pairs into a 4-bit code.

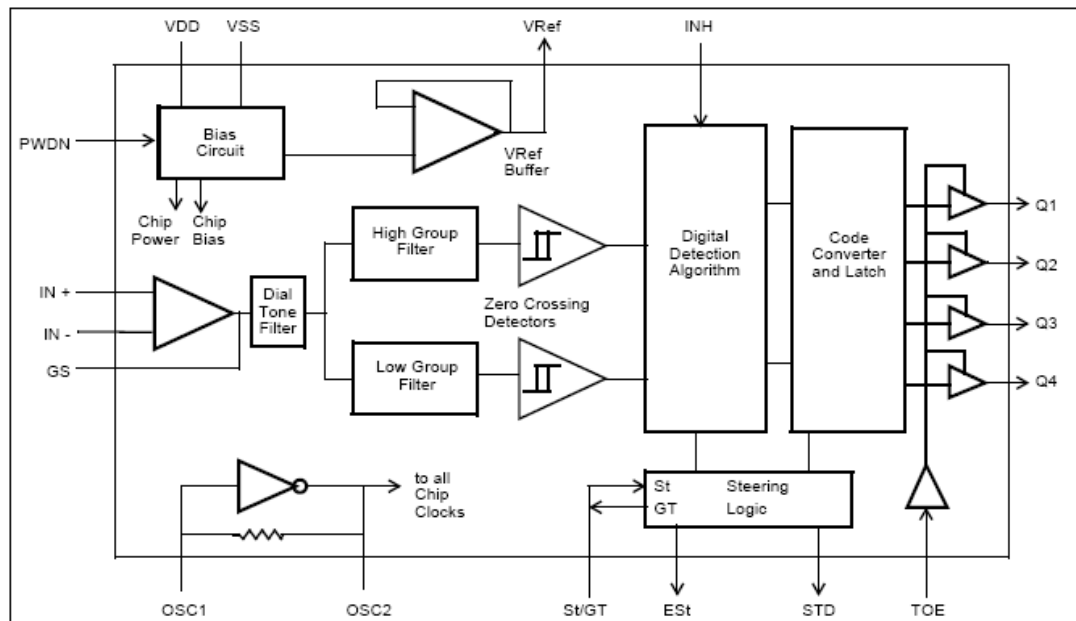


Figure 1 - Functional Block Diagram

External component count is minimized by on chip provision of a differential input amplifier, clock oscillator and latched three-state bus interface.

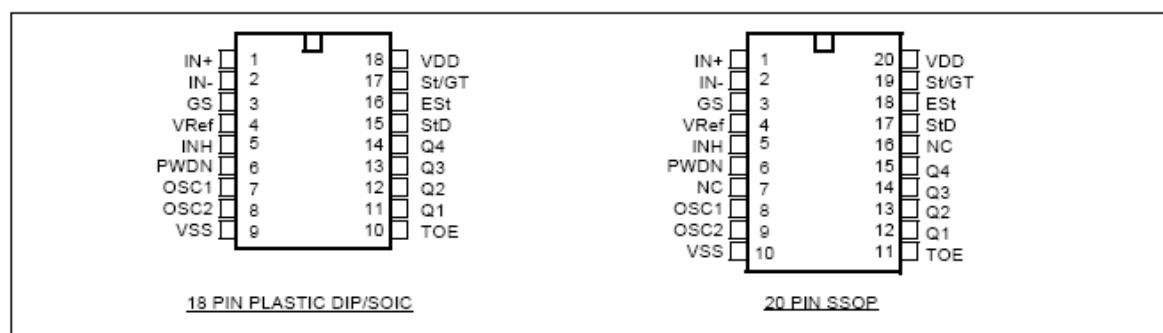


Figure 2 - Pin Connections

Pin Description

Pin #		Name	Description
18	20		
1	1	IN+	Non-Inverting Op-Amp (Input).
2	2	IN-	Inverting Op-Amp (Input).
3	3	GS	Gain Select. Gives access to output of front end differential amplifier for connection of feedback resistor.
4	4	V _{Ref}	Reference Voltage (Output). Nominally V _{DD} /2 is used to bias inputs at mid-rail (see Fig. 6 and Fig. 10).
5	5	INH	Inhibit (Input). Logic high inhibits the detection of tones representing characters A, B, C and D. This pin input is internally pulled down.
6	6	PWDN	Power Down (Input). Active high. Powers down the device and inhibits the oscillator. This pin input is internally pulled down.
7	8	OSC1	Clock (Input).
8	9	OSC2	Clock (Output). A 3.579545 MHz crystal connected between pins OSC1 and OSC2 completes the internal oscillator circuit.
9	10	V _{SS}	Ground (Input). 0 V typical.
10	11	TOE	Three State Output Enable (Input). Logic high enables the outputs Q1-Q4. This pin is pulled up internally.
11-14	12-15	Q1-Q4	Three State Data (Output). When enabled by TOE, provide the code corresponding to the last valid tone-pair received (see Table 1). When TOE is logic low, the data outputs are high impedance.
15	17	StD	Delayed Steering (Output). Presents a logic high when a received tone-pair has been registered and the output latch updated; returns to logic low when the voltage on St/GT falls below V _{TSt} .
16	18	ESt	Early Steering (Output). Presents a logic high once the digital algorithm has detected a valid tone pair (signal condition). Any momentary loss of signal condition will cause ESt to return to a logic low.

Pin Description

Pin #		Name	Description
18	20		
17	19	St/GT	Steering Input/Guard time (Output) Bidirectional. A voltage greater than V_{TSt} detected at St causes the device to register the detected tone pair and update the output latch. A voltage less than V_{TSt} frees the device to accept a new tone pair. The GT output acts to reset the external steering time-constant; its state is a function of ESt and the voltage on St.
18	20	V_{DD}	Positive power supply (Input). +5 V typical.
	7, 16	NC	No Connection.